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Contents—Page 51

Heating · Piping and Air Conditioning

n • Installation
ion • Maintenance

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arge Buildings

NAL DEFENSE—What mean to you? Read T. hl's informed comments s 47 and 48, front sec- He clarifies some con- oints

NG by reversed refrig- sounds strange, but can is—done. A. J. Law- cribes the details of an ion in New England on 19-521 this month

INSULATION is the of E. T. Cope and W. ney on pages 524-526. nclude information on gh temperature and low ature piping

TRIAL air conditioning es involves dehumidi- nd heating, like the Aires job described by A. Ramsey on pages 522 . The solution is novel

MORE—Radiant heat- e 527; ship heating and ion, page 529; centrifu- igeration, page 534; cost m (data sheet), page air conditioned hospi- e 539; the ring joint, 8—these are a few of er articles this month

Page 555
ournal Section
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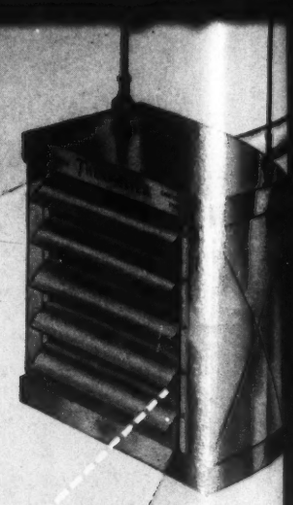
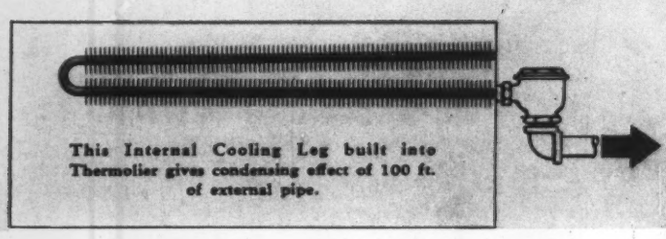
ating Engineers

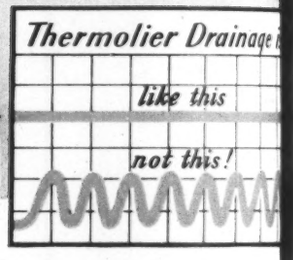
THERMOLIER EFFICIENCY *BEGINS* WITH...

THIS ADDED "FULL HEAT" ZONE!





This Internal Cooling Leg built into Thermolier gives condensing effect of 100 ft. of external pipe.



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THE UNIT HEATER WITH 14 POINTS OF SUPERIORITY

Heating · Piping and Air Conditioning

with which is merged the "Aerologist"

Design, Installation
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in Industry and Large Buildings

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CONTENTS *for* SEPTEMBER, 1940

Volume 12 — Number 9

What Does National Defense Mean to You?, by T. H. Urdahl (front section) 47

Heating by Reversed Refrigeration, by A. J. Lawless 519

Dehumidifying and Heating Needed on an Industrial Air Conditioning Job, by Melvin A. Ramsey 522

Double Standard of Comfort for Men and Women 523

Insulation of Piping, by E. T. Cope and W. F. Kinney 524

Outdoor Temperature a Minor Factor in Air Conditioning Load 526

Air Conditioning a Modern Necessity 526

Radiant Heating and Cooling, by F. E. Giesecke 527

Heating, Ventilating and Air Conditioning on Shipboard, by John H. Clarke 529

Turbine Driven Centrifugal Machine Improves the Plant's Heat Balance, by W. S. Bodinus 534

Piping Does Double Duty, by David E. Alton 535

Northwestern Builds Technological Institute 536

Cost of Steam With Coal as Fuel (data sheet), by Irving E. Brooke 537

Combination of Central Plant and Unit Air Conditioning Serves Varying Needs, by F. H. Chisholm 539

Air Conditioned Steamboat 'Round the Bend!, by J. H. Bailey 542

"Open for Discussion" (Communications to the Editor) 543

How Much Steam for Heating? 545

Air Conditioning Guards Knife Blades from Rust, by J. T. Schaefer 547

Air Conditioned Super-Market, by J. L. Rosenmiller 547

Here's Where Air Conditioning Is Used 547

The Use of the Ring Joint on Oil and Steam Piping Service, by F. R. Venton and A. W. Marburg 548

Absorption Refrigeration for Air Conditioning, by W. F. Friend 551

Heating a Garden Apartment Project, by Herbert Raisler 553

Heating Abroad and at Home, by Sam Lewis 554

Equipment Developments (back section) 116

Industrial Health Defense (back section) 132

Book Reviews (back section) 136

Booklets, Reports and Papers (back section) 136

Conventions and Expositions (back section) 138

Recent Trade Literature (back section) 140

Index to Advertisers (back section) 146

[Front cover photo from R. I. Nesmith and Associates]

Journal Section of the American Society of Heating and Ventilating Engineers

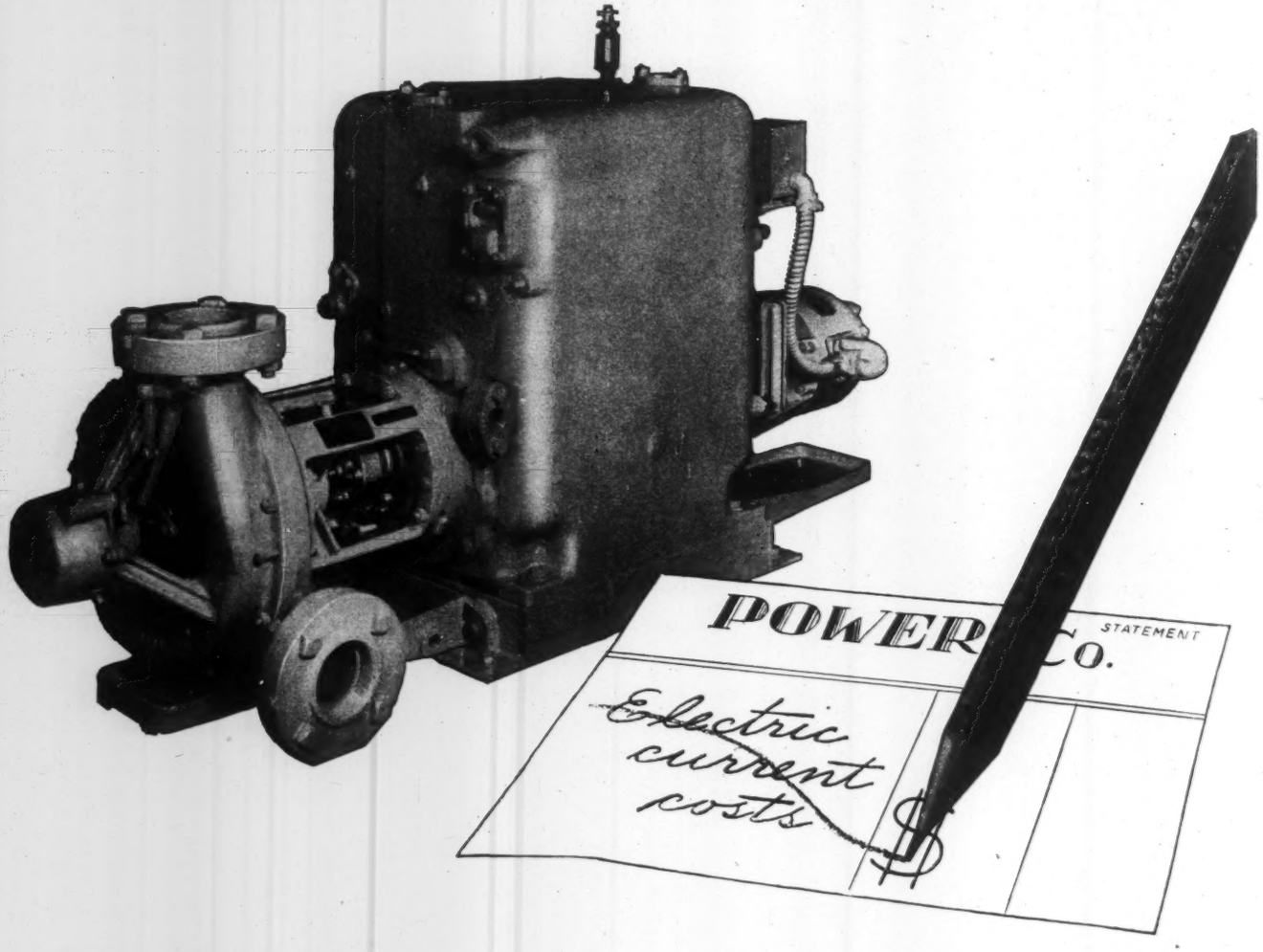
Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl 559

Attenuation of Sound in Ducts of Commercial Size, by R. B. Steffens and W. T. Young 567

Heating, Ventilating and Air Conditioning Courses 573

Bulletin Section 576

A NASH VAPOR TURBINE HEATING PUMP WILL ELIMINATE THIS EXPENSE ITEM.



The Jennings Vapor Turbine Return Line Vacuum Heating Pump requires no electric current, eliminating the one biggest expense item in the operation of an ordinary return line pump. This is because the motive power is a special turbine operating on steam direct from the heating system. Steam used to drive the turbine is returned to the system for heating, with little heat loss.

The really important saving promoted by the Jennings Vapor Turbine is in the system itself, however, for this is the only heating pump that can operate continuously with economy. Continuous operation means uniform circulation, and uniform circulation means a big saving in steam.

This pump has but one moving part, no internal wearing parts, and no internal lubrication. It is compact and quiet, and will give long and satisfactory service at the lowest maintenance cost. Bulletin No. 246 tells all about it. It is free on request.

THE NASH ENGINEERING COMPANY

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THE EDITOR'S PAGES

What Does National Defense Mean to You?

Editor's Note—A question uppermost in almost everyone's mind is "What does the national defense program mean to me?" In an endeavor to clarify some of the conflicting reports emanating from various sources, we've asked T. H. Urdahl, consulting engineer of Washington, D. C., to express his informed opinion for the benefit of engineers and contractors in the heating, piping and air conditioning fields. Mr. Urdahl's personal interests, agreeing as they do with those of our readers, and his familiarity with the Washington scene, well qualify him to comment instructively on this important question.

EVERY person in the United States, directly or indirectly, has a part in the national defense program, especially in thought and in attitude if not also in immediate service. It should be realized especially by those in construction, manufacturing and engineering that the defense program is real and not a state of mind. Its execution requires the best effort at the greatest speed, at a cost and sacrifice to everyone.

Upon engineers and scientists depends the development of adequate defense. To them as professional men, and to contractors and manufacturers, the construction program for national defense is of greatest interest. We hear many questions about this program. How is it being handled? Who gets the work? Who does the work? How does one get the work? We know most of the questions, few of the answers. It is easy to ask questions, but answers must be found.

The most frequent question, "What can I do", is difficult for anyone to answer except in a preliminary way: (1) Do not look upon the magnitude of the construction program as a "banquet table" set for the construction industry, as some seem to view it. (2) Stick to your own work. Don't set up a new organization in hope of getting some "profitable war business." (3) Prepare to do the job to which you will be assigned rapidly and well.

In letting contracts, purchasing materials, and planning buildings and defense works, the officers responsible are obliged to obtain the best at the best and lowest price consistent with time allowed for delivery; and remember—time may be worth more than money! Necessarily, the procedures developed to meet these responsibilities are chiefly affected by the quantity of available trained personnel to administer these huge programs and the fitness of manufacturing or contracting organizations and individuals to execute, in short order, the work with which they are charged.

Politics? Of course, politics plays some part in some awards. It always has and probably always will, but not to any large extent in this program. (At least we hope so.) First, because those

charged with its administration have too big a job on their hands to find time for delay which cognizance of political factors always entails, and secondly, because our army and navy officers, upon whom much of this grave responsibility rests, cannot be swayed by personal or political considerations without violation of that trust of command which they have sworn to uphold.

On the surface it might appear that the setup is 90 per cent political in the method of lumping of many small contracts into one and the granting of large contracts to the big contractors who have in the past and are now doing the major share of the government construction. No doubt, political ammunition will be made of this apparent condition.

Construction contracts in which heating and air conditioning engineers, contractors and manufacturers are primarily interested are for the most part of the negotiated fixed fee type made by the offices of the constructing quartermaster of the army and the bureau of yards and docks of the navy. They are fair, do not contain jokers, contemplate payment for all items of labor, material, and incidentals, plus fixed fees agreed upon by the contractor and awarding authority as fair compensation for the government's use of the facilities of a going concern, its managerial ability and capital.

Fees ordinarily vary inversely with the size of the contract. It should be the patriotic, as well as the practical consideration of *everyone*, to keep them at an absolute minimum. You would not charge yourself a profit on your own misfortune! National defense is unfortunate business; but it is our business.

Upon analysis of some of the practical and economic aspects of politics which have been questioned in the award of contracts, substantial facts may be discovered in answer.

Lumping Several Jobs Under One Contract

Pro: Facility of administration—for speed.
Less administration personnel—for lower cost.
Better coördination of purchase—for lower cost.
Lower "overall" fees.
Con: Less attention to each respective job.
More mistakes.

At present the larger operators are in many instances the best organized and can proceed expeditiously, but there are limits to the amount of work which they can do. The major part of the program, not yet contracted for, must inevitably be carried out by the many smaller firms and offices.

Design and Construction Under One Contract

Contracts have been made by both the constructing quartermaster and the bureau of yards and docks in which design, engineering, and construction are carried on coöperatively by consulting engineers, architects and one or several contractors. The principle is sound, since it is only through the close coöperative effort of the designer and the contractor that the best results are obtained in the shortest time. This method is regularly followed by many large industrial organizations.

But this practice cannot, in all cases, be generally followed with satisfactory results. Coöperation as between engineer or architect and contractor is not something that can be ordered, at least under present conditions. The prerogatives of each and their differences in thought and work cannot be ignored.

It is, however, an unfortunate truth that the offices of many architects and engineers are not administratively geared to do a job quickly. They spend a seem-

ingly impossible time fooling around before they really get going. There is nothing quite like having a contractor who is itching to go and has a time limit in which to do his work to prod them along. The need is for organizations with an "over drive" instead of the conventional set of gears, in which many operate in "low" all the time.

Contract Fees

The act of congress of June 28, 1940, sets 7 per cent as the maximum fee which can be paid on negotiated contracts. While a definite interpretation of the intent of the law is not yet available, it is assumed that a fair fee is intended on general and sub-contracts alike or that sub-contracts be on a fixed price basis. If the maximum shall include all fees, as it has been interpreted in some instances, it will tend to encourage general contractors to set up their own sub-contracting departments instead of dealing with those already organized and established in the trade. It is at once apparent that this departure from established method means added administrative difficulties, a headache to the general contractor, and a possible loss in efficiency and speed to the government, which will not be tolerated.

Direct Sub-Contracts

The direct sub-contracting of work in mechanical trades is both desirable and economical where such work constitutes the major portion of the project. Otherwise it involves added administrative detail and provides a loophole for "buck-passing," especially on delays.

The practice of direct sub-contracts, so far, is more general in the work of the constructing quartermaster.

Administrative Personnel

A shortage of personnel for highly responsible positions in the army to supervise and administer the construction program has resulted in a canvass of reserve officers, colleges, universities and other available sources. Out of those available, an absurdly small number qualify.

The service wants men who are tops in professional standing, physique, alertness, ability, habits, appearance and personality. Lower salaries, $3000 to $3600, attract men of correspondingly lower abilities. There is the danger that responsibility above the qualification of the individual will result in the human failing of masking ignorance with abuse of authority. Higher salaries, while attracting personnel of higher caliber, bring a possible danger of attraction of those whose chief qualifications are membership among the "politically faithful."

We hope that the jobs are not permanent. The men who could volunteer to fill them and meet the major qualifications have jobs at higher salaries, and they have obligations and responsibilities commensurate with those salaries. It should be possible to employ civil personnel under civil service grading and selection at higher rates of pay. Giving up one's job or business is a large sacrifice. The "dollar a year" men are patriotically generous, but they also have independent means.

Engineers, architects and supervisors with administrative experience and ability are needed. Undoubtedly, machinery will be set up, if not already so, to "borrow" these at not too great an economic sacrifice.

The mechanics of war now call forth the best in skill of the technically trained, but the calling will be an orderly, effective procedure. A roster now in preparation will list and classify all who are engaged in technical and scientific pursuits. This in itself is a large order, as it will contain 500,000 names. Workers engaged in research, testing, development, production, and design will be catalogued so that the man for the job can be quickly found. It may be discovered that in the majority these men will serve best at their present jobs, possibly with some change in objective, requiring greater effort and without doubt, longer hours.

EUDYPTULA MINOR

A development which probably should not pass without being noted in these pages—if it should be noted anywhere—is the position the penguin now holds as the symbol for summer air conditioning or cooling. This diminutive, dinner jacketed creature has far outstripped the polar bear or icicles during the last two or three summers for identifying air conditioned establishments. In wood or plaster he stands in the window of many a comfort-cooled store and restaurant to invite passersby to enjoy relief from sidewalk heat. He has even appeared in the flesh at air conditioning exhibitions. Many will feel he should be given a place with Benjamin Franklin as co-patron of the heating and air conditioning arts.

The penguin is—says Webster—a short legged, flightless aquatic bird, most numerous about the Antarctic continent, Falkland Islands and New Zealand. On land he stands erect but walks clumsily, he is covered with stiff, scale-like feathers and has flipper-like wings. His favorite dish is shellfish. The largest species are the king penguins which stand about three feet high, and the smallest penguin (*Eudyptula minor*) is about a foot long. That's all we know about them.

REPORTS NET INCOME UP

The semi-annual report of Carrier Corp. reveals net income, for the six months ended June 30, 1940, of $278,698.45, equivalent to 71c each on the 390,808 shares of common stock outstanding. The comparable figure for the first half of 1939 was $147,642.41, or 38c per share.

Completed sales for the first six months of 1940 were 7.1 per cent less than those of the corresponding 1939 period. Unfilled orders totaled $4,504,023 as of June 30, 1940; a year earlier they amounted to $3,275,701. Orders booked during the first half of 1940 were slightly smaller in amount than those of the same period last year. During recent weeks the trend of new orders has been upward and second quarter bookings were 3.6 per cent larger in 1940 than in 1939.

ORDERS BOOKED AND SALES INCREASE

In a letter to stockholders of York Ice Machinery Corp., Pres. Stewart E. Lauer reported last month that orders booked during the nine months ended June 30 totaled $12,560,931, against $11,396,429 in the same period last year. He also reported $8,589,596 of sales completed, against $7,876,752 a year ago.

ACMA AND RMA COMBINE

The Air Conditioning Manufacturers' Association and the Refrigerating Machinery Association have announced a combination of their activities. The new association is known as the Air Conditioning and Refrigerating Machinery Association. Primary result of the combination will be a broadened scope of operations, with particular attention being given to equipment standardization in the commercial refrigeration and air conditioning fields.

Heating · Piping and Air Conditioning

Vol. 12, No. 9 • September, 1940

Heating by Reversed Refrigeration

Design, Operation and Control of Reversed Cycle System for Utility Company Building Explained by A. J. Lawless*

THE reversed refrigeration cycle is used for heating the new administration and service building of the United Illuminating Co., the utility serving New Haven, Conn., Bridgeport and surrounding communities. The two natural sources from which heat may be extracted in winter are outside air and water. In cold climates, water is the more practical source and in the present case six deep wells with a total capacity of 600 gpm of 55 F water are used. The well water is pumped first to a large baffled settling tank having a capacity of 6000 gal. In it, all sand is settled out of the system. From this tank the water for the system is pumped through the refrigeration evaporators.

The capacity of the circulating pump under the maximum heating requirement is 400 gpm. As the capacity of the wells is greater than the maximum requirement of the system, not more than four wells are in operation at one time. The operation of the well pumps is controlled by four float switches set at different levels in the settling tank. These float switches are electrically jacked so that any one of the six well pumps may be operated from any one of the four float switches. This allows the operator to interchange well operation. The well water after leaving the evaporators may be returned to the two wells not in operation, which tends to maintain a higher pumping level for the wells in operation.

The refrigeration plant consists of eight separate units each with an evaporator, condenser, and a compressor driven by a 40 hp motor. The eight evaporators are in parallel in the well water circuit, each being furnished with 50 gpm, and they have an aggregate capacity to cool 400 gpm from 55 to 40 F. The condensers are in series in the heating water circuit and have an aggregate capacity to raise the condenser water from 102 to 124 F.

Each compressor unit is provided with the necessary safety controls to assure against breakdown, including dual high pressure cutouts, low pressure and low temperature refrigerant cutouts, low water temperature cutouts and oil failure cutout. In addition each compressor is provided with an operating hour meter and the entire system was installed through an electric switch, so that the sequence of operation of the eight compressors under automatic control can be changed by the operator to assure equal wear and depreciation.

*Partner in the firm of Hubbard, Rickerd and Blakely, Consulting Engineers.

The entire refrigeration plant with interconnecting piping is mounted on one spring supported base, and all piping leading to and from the system has vibration eliminators in order to insure against the transmission of noise. The well water piping is red brass and the "Freon" refrigerant lines are copper tube. Wrought iron piping is used for local circulation of heating water.

Basis of Heating Design and Control

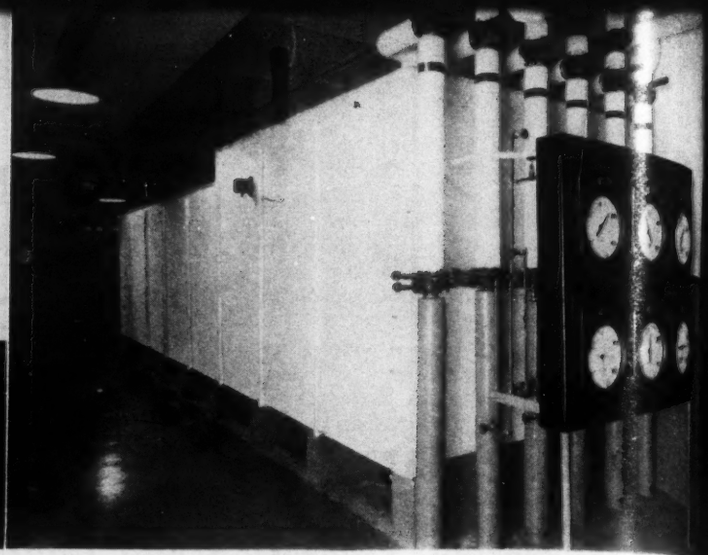
This reversed cycle heating system was designed on the basis of 20 F above the base temperature of 0 F outside. It therefore has at this temperature the capacity to raise the condenser water temperature from 102 to 124 F, and all heating equipment had to be designed to maintain temperatures when furnished with 124 F water from the reversed cycle system without further boosting.

As the outside temperature rises above 20 F the temperature of the delivered water is automatically decreased and controlled from an outside compensating thermostat. The thermostat in the water leaving the condensers

SUMMARY

The new three story administration and service building of the United Illuminating Co., New England utility, is heated by a reversed cycle refrigeration system using six wells supplying 55 F water as the source of heat in winter. The well water is pumped first to a 6000 gal settling tank where sand is settled out, and then goes through the refrigeration evaporators. After leaving the evaporators, the well water is returned to the ground... The refrigeration plant consists of eight separate units, the eight evaporators being in parallel in the well water circuit and the condensers in series in the heating water circuit; the condensers have an aggregate capacity to raise the condenser water from 102 to 124 F . . . As the outside temperature decreases below 20 F, the base temperature used in design of the reversed cycle system, a portion of the heating circuit water is boosted in temperature by direct electrical conversion heating. This boosting system is designed to operate during offpeak hours at night; it consists of a 480 kw heater, a 7000 gal storage tank, circulating pumps and a heat exchanger between the storage system and the building heating system . . . Complete control of all of the elements of this heating and air conditioning installation has been provided, and its operation is explained in detail in the text. Meters are also provided for obtaining operating data after a full year's use, and the author plans to publish such data in HEATING, PIPING AND AIR CONDITIONING

This three story utility building is heated and air conditioned by an all-electric system, reversed cycle refrigeration using heat from 55 F well water being the source of heat in winter. The well water .....



..... first goes to this 6000 gal sand settling tank, where all sand is settled out, and is then pumped through the evaporators of the refrigeration units, which are in parallel in the well water circuit. The condensers .....

starts and stops the compressor units as dictated through a program switch. The volume of the condenser water remains constant and passes through the shutdown condensers without added heat. This method of operation gives lower discharge temperatures and increases the ratio of performance. As a compressor is shut down, the well water through the evaporator is automatically stopped, decreasing the well water discarded from the system.

As the outside temperature decreases below 20 F and all heating and ventilating apparatus is in operation, all eight compressor units are in continuous operation delivering 124 F water. A portion of this water is boosted in temperature by direct electric conversion heating, approaching a maximum of 140 F as the outside temperature approaches the design temperature of 0 F. The delivery temperature of this unit is also controlled through an outside compensator thermostat.

The heating apparatus for the building is divided into two general circuits, one containing heating and cooling units and the other heating units only, as shown by the flow diagram on p. 475 of the August HPAC. In the thermodynamic balance of the total heat losses of the building against the capacity of the reversed cycle system plus the direct heating system, it was determined that boosting by direct heating would be required for only those units indicated in the heating circuit.

Heating and Ventilating Garage Areas

In the engineering of this circuit it was decided that the garage areas could be properly heated and ventilated with secondary water from the ventilation heaters and convectors and the garage units are therefore installed in series with the ventilation heaters and convectors. This method has the advantage of decreasing the total water circulated and lowering the temperature of the return water to the condensers, maintaining a maximum performance ratio.

The convectors in the system are installed, in addition to locations already stated, in such areas as hallways, stairways, small toilets and service offices not air conditioned. Other similar areas, such as large outside toilets having exhausts causing excessive heat losses, are heated with unit heaters, it being impractical to install sufficient convector surface for the proper heating with the low water temperature available. The water flow through these heaters is in parallel with the flow through the convectors.

The garages are heated in the usual manner with unit heaters distributed throughout the areas automatically controlled from local thermostats.

In the design of the garage ventilation, it was considered of prime importance to avoid unwarranted operation of the equipment during the heating season. The garage is divided into three general areas each separately ventilated with an exhaust fan with collecting ducts, and an outside air supply fan and heater assemblies of the unit ventilator type. The operation of both the supply and exhaust systems of each area during the heating season is controlled by a carbon monoxide controller.

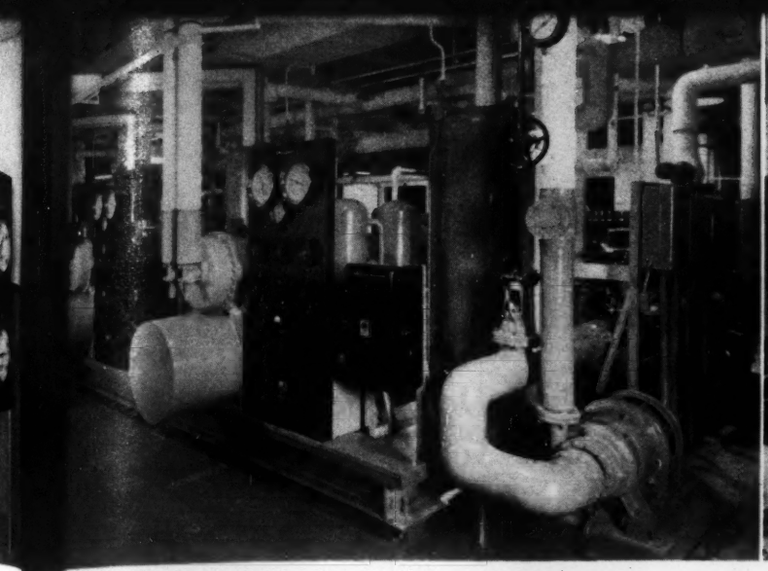
By this method of division and control it is seldom if ever that the heating plant will be called upon to heat the combined 24,000 cfm capacity of supply units at any one time.

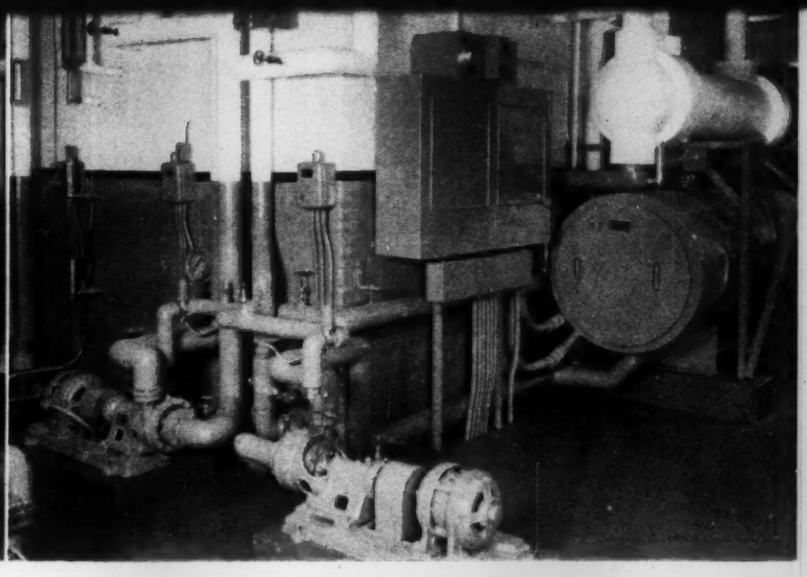
Zoning the Heating

When the unit ventilators are not in operation the heating water bypasses back to the circuit, increasing the temperature of the return water to the condensers. Above 20 F outside, this allows additional compressor units to be inoperative. Below 20 F outside, the compressor units have the capacity to deliver water at higher than their design temperature of 124 F, decreasing the heat required from the booster system. The increased delivered temperature from the reversed cycle system is also controlled by an outside compensating thermostat.

This method of operation and control made it necessary to design the units in the heating circuit not affected by the booster heater so that they would properly function when furnished with either 124 F or upwards to 135 F water as the outside temperature decreased from 20 to 0. In this circuit, in addition to the central and business office units, the air conditioned section of the building is divided into three zones, each zone containing approximately 20 heating and cooling units.

A local pump is provided for each zone. This pump draws water either from the general heating system or zone recirculating system as dictated by the zone thermostat. As the heating elements are designed for full





..... of the eight separate refrigeration units are in series in the heating water circuit and have an aggregate capacity to heat the condenser water from 102 F to 124 F. When the outside temperature falls below 20 F.....

heating requirements with 124 F water, the fluctuating water temperature does not effect the operation within the zone. The central office unit and the business office unit are each provided with a straight bypass returning the water not required by the heaters direct to the system without loss in temperature.

Boosting System Operates Offpeak

The electrical boosting system is designed for offpeak operation, drawing electrical energy only at night and storing the converted heat for daytime use. It consists of a 480 kw heater, a 7000 gal water storage tank, circulating pumps and a heat exchanger between the storage system and the building heating system.

During the night and under the control of a time clock, water at 150 F is pumped from the bottom of the storage tank through the electric heater and delivered to the top of the storage tank at 350 F. When booster heating is required, water at 350 F is pumped from the top of the storage tank through the heat exchanger and delivered to the bottom of the storage tank at 150 F.

Under maximum booster requirements the entire 7000 gal is cooled from 350 to 150 F by the heat exchanger in one day's operation. Under less than full load only part of the 7000 gal is cooled and the storage tank at the end of operation contains water in stratification, with 350 F water at the top and 150 F water at the bottom. Night charging under less than load is continuous only until the 150 F water is pumped from the bottom of the tank and returned at the top at 350 F.

The operation of the system is entirely automatic, and in order to prevent over heating, the electric heater is divided into four circuits, each circuit automatically controlled from the discharge water temperature. As the system is operating under high pressure it is also provided with the usual safety controls that would apply to a high pressure boiler.

An auxiliary electric heating system the exact duplicate of the above has also been installed. This system is so installed in the circuit with all the necessary cross connections so that it can be used in part or in full as a spare or as a means of doubling the capacity of the boosting system. It also functions as an auxiliary for the compressor systems.

..... this direct electrical heating system provides the additional heating required. It comprises an electric heater, circulation pumps, storage tank, and heat exchanger, and heats water for use the next day during offpeak hours at night

Changing from Heating to Cooling

The system is changed from heating to cooling service by resetting several shutoff valves and changing the position of the automatic control switch. This switch reverses the action of all thermostats controlling the operation of all units in the circuit fed with hot water in the winter and cold water in the summer. It also changes the operation of the compressors from the thermostat in the water leaving the condensers to a thermostat in the water leaving the evaporators. This thermostat, compensated from an outside thermostat, regulates the temperature of the delivered water to the cooling units by operating the refrigeration compressors. Full flow is maintained by bypassing the evaporators when they are not in operation.

The flow of well water is regulated, in order to keep the well pump operation at a minimum, by the controls at the cooling units. Those units furnished with cooling water only are provided with throttling type control, and the bypasses of other units are restricted in order to reduce the flow to a minimum under less than full load.

The well water after passing through the cooling units is returned to the condensers, acting as the condensing medium for the compressors in operation before being discarded. It is therefore necessary that a certain minimum flow of well water be maintained. This is accomplished by balancing the delivered water temperature and capacity so that under all conditions of operation the controlling valves at the units are always in a partly or full open position, maintaining a flow above the minimum.

As the system has been in operation only for approximately one month under mild heating conditions, it has been impossible as yet to obtain accurate operating data. There have been installed in the system all the necessary flow meters, recording thermometers and electric meters in order that accurate data may be obtained. It is the intention of the author to publish the data in HEATING, PIPING AND AIR CONDITIONING after a full year's operation.

[This is the second of two articles describing this unusual heating and air conditioning installation. The first, published in the August HPAC, explained the principle of heating by means of the reversed refrigeration cycle and included a simplified flow diagram of the entire heating and cooling system.]

Dehumidifying and Heating Needed on an Industrial Conditioning Job

Melvin A. Ramsey*, Buenos Aires Reader, Describes How Air Conditioning System for Rotogravure Room Operates

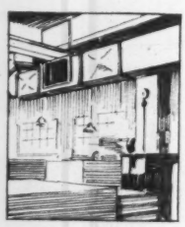
SUMMARY

The author describes the re-arrangement of an air conditioning system serving the rotogravure room of a large Buenos Aires publisher, which was installed to maintain about 70 to 72 F dry bulb and 55 to 65 per cent relative humidity. . . . . Because of a process water bath in the room, dehumidification is always required. The revision of the original installation eliminates any fuel consumption for heating the room and makes it unnecessary to change the heating coil from the heating system circuit to the condenser water circuit each year

AT the beginning of the southern hemisphere's summer of 1938-39, one of the large publishers in Buenos Aires contracted for an air conditioning installation to maintain about 70 to 72 F dry bulb and 55 to 65 per cent relative humidity in a rotogravure room.

To maintain the desired conditions, reheat was needed in summer. To maintain the desired humidity in summer, the air had to be dehumidified by being cooled. Because the sensible heat load is not great enough to heat the air to the desired room temperature, additional reheating is needed. An inspection showed that steam was not available for reheating. The existing heating system used circulating hot water, and this circulating hot water is available only in winter. Therefore, we decided to use warm condenser water for reheating the air. The water leaving the condenser flows through the counterflow heating coil shown in the illustration. The flow of the warm condenser water through the heating coil is controlled by means of a motorized three way valve controlled from a thermostat in the return air from the rotogravure room.

For winter, when we anticipated that heating and humidifying would be required, the owners were told that a connection should be made to their heating system and that a circulator for forcing the hot water through the heating coil used for summer reheating would be required. However, a check-up of the heating system showed that the installation of a circulator would probably unbalance the heating system very badly unless the location of the connections was changed to a point much nearer the boiler. Because of the expense involved, it was decided to install only the air conditioning system, leaving the circulator and the new connections to the heating system to be installed at a later date. When the air conditioning system was installed, hot water connections to the heating system were made directly to the heating coil without a new circulator being installed.

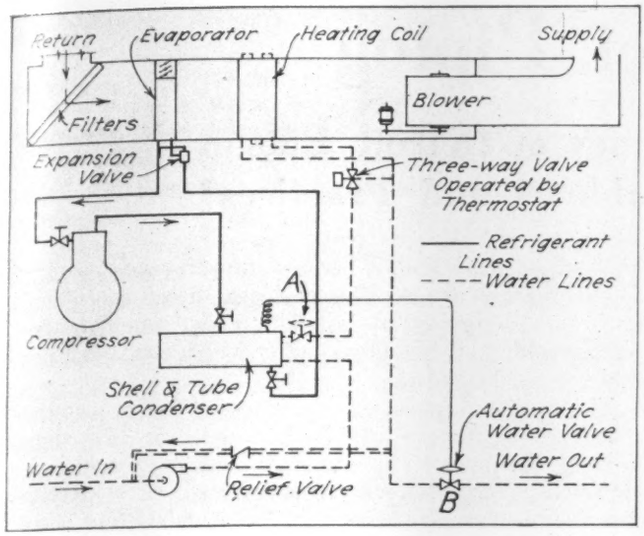


During the first summer and early fall, the performance of the system was very satisfactory. When the outside temperature fell to about 60 F, the hot water valves were opened and the condenser connection bypassed. However, without a circulator, the heating was not satisfactory and the owners called us in. They asked us if we could not find a simpler way to do the job than by installing a circulator and the new connections near the boiler. Also, the owners were now in a considerable hurry because the temperature had fallen to freezing (32 F is about as low as is normally experienced in Buenos Aires, about 23 F being the lowest on record). We made an inspection on a day when the temperature was about freezing and found that the compressor was operating in order to hold the relative humidity of the rotogravure room down. In doing so, the room air was being cooled, and a temperature of about 58 F was being maintained (this rotogravure room had no heat but only its ceiling is exposed and it is surrounded by other rooms kept at about 68 F). Even on as cold a day as we would expect in Buenos Aires, dehumidification was required. Furthermore, we found that a hand valve in the supply to the spray nozzles had never been opened after the water connection was made and that the humidity had never been too low. The reason for this was that the moisture from water at 105 F in a process bath had always supplied more humidity than was desired. After we learned this, the valves in the piping to the heating coil were changed to use condenser discharge water at about 70 F. The temperature in the rotogravure room naturally rose, but not enough. If the water could be discharged to the heating coil at 95 F, conditions would be much more satisfactory and it would be possible to maintain the rotogravure room at a higher temperature.

Using Condenser Water for Heating

The method used to obtain condenser water at 95 F is simple and required no equipment not readily available. The illustration shows the system just as it is now except for the original hot water connections which are not of importance in this description. The only changes made from the original circuit were the addition of the pipe connection shown by a double broken line and a new relief valve in this line. Also, the automatic condenser valve was changed from the original position marked *A* on the illustration to the new position where it is now located, which is marked *B*.

*Arnott & Co., Ltd., Buenos Aires.



The system as it is now, except for the valved well water supply and hot water connection, which are not of importance in the author's description. The only changes made from the original circuit were the addition of the connection shown by a double broken line with its relief valve, and the removal of the automatic condenser water valve from *A* to *B*. The relief valve is set to provide just a little more resistance than is required to push the maximum quantity desired through the automatic valve

In operation, if the humidity in the rotogravure room rises, the humidistat will start the compressor. The condenser water leaves the condenser at about 70 F. The automatic water valve *B* cannot open unless the condenser pressure is at such a point that the leaving condenser water will be about 95 F. Consequently, the automatic water valve *B* will remain closed and the water first supplied to the condenser will be recirculated through the relief valve to the suction of the pump. This water will be continuously recirculated until the temperature of the water leaving the condenser is about 95 F. At this point, the condenser pressure will be high enough to open the automatic water valve *B*. Some water will be wasted and sufficient make-up water will be taken in to maintain the condenser pressure at the setting of the valve *B*. When this occurs, sufficient water will be continually admitted so that the temperature of the water leaving the condenser will be maintained at 95 F.

Controlling Make-Up Water

The quantity of make-up water admitted depends upon the position of the automatic three way valve controlling the bypass around the heating coil. If the temperature in the rotogravure room is below the setting of the thermostat, the thermostat will set the motorized three way valve in such a position that the 95 F water leaving the condenser will flow through the heating coil. In this case, the temperature of the water will be lowered as it flows through the heating coil. If a great deal of sensible heat is required to raise the temperature of the room, the temperature of the water may be lowered in the heating coil to such a point that the pressure in the condenser will fall and the automatic water valve *B* will close. In this case, no fresh make-up water will be admitted. All of the heat rejected to the condenser water will, in turn, be rejected by the water to the air flowing through the heating coil. On the other hand, if the temperature of the room rises above the setting of the thermostat, the motorized valve will assume such a position that the water is bypassed around the heating coil. In this case, the temperature of the recirculated water will rise sufficiently to open the automatic water valve *B*. In this case, sufficient make-up water will be drawn into the system to maintain the condenser pressure at the setting of the valve *B*.

The comparatively simple change involved in setting the new bypass connection shown by the double broken line in the illustration, the addition of a new relief valve, and the change in the location of the automatic water valve from *A* to *B* eliminates any fuel consumption for heating this room. In addition, it is no longer necessary to change the heating coil from the heating system circuit to the condenser water circuit and back each year. Naturally, such a scheme will not be satisfactory for maintaining these conditions in all climates—or even in this climate for rooms which have no humidity output. If humidity removal were not always required, this system would not always be capable of supplying sensible heat.

Double Standard of Comfort for Men and Women

A "double standard of comfort" for men and women was recently described by Professor C. P. Yaglou of the Harvard School of Public Health before the annual meeting of the American Industrial Hygiene Association. Conducted with groups of men and women in experimental rooms where the temperature and humidity were accurately controlled by air conditioning, his studies revealed that women almost invariably prefer higher temperatures for comfort in both summer and winter. He attributed this to clothing habits, although differences in the constitution of men and women appeared to be partially responsible.

Due to Clothing

The conclusion to be drawn from these tests, Professor Yaglou declared, is that differences of comfort standards between men and women, and individual differences, are primarily due to differences in dress, and could be reconciled by adjustments of clothing, according to susceptibility to cold or heat.

"If women would dress in winter with clothes that are comparable in warmth to those of men, they would be comfortable in a temperature of about 72 F, instead of 76 F at present, and there would be less discord in the matter of room temperature. Reversely, if men would take off their vests, coats and collars in hot weather, buildings would not have to be cooled much below 85 F, instead of 76 to 80 F at present, and much of the difficulty now experienced with temperature contrasts would be alleviated.

"Incidentally, reconciliation of the double temperature standard would also greatly simplify the problem of the engineer and would reduce the expense of heating and cooling buildings."

Insulation of Piping

E. T. Cope and W. F. Kinney of Detroit Edison Discuss Some of the Problems and Practices*

SUMMARY

A study of heat insulation problems in steam power plants resolves itself into a consideration of the convenience of application, cost of construction, and permanence as related to installations on furnace walls, ducts, fan housings, piping for hot and cold fluids and steam turbines. Certain problems are encountered in producing an economical, permanent and neat installation—for some, satisfactory solutions have been reached, with others progress has been made, and still others exist that have been recognized only recently. . . . . Believing that improvements can be made most rapidly by bringing into the open the problems involved, Messrs. Cope and Kinney pointed to some of them and described some unusual techniques of installation at the recent semi-annual meeting of the ASME. We have taken here only those sections pertaining directly to piping, and present them by permission as of interest generally

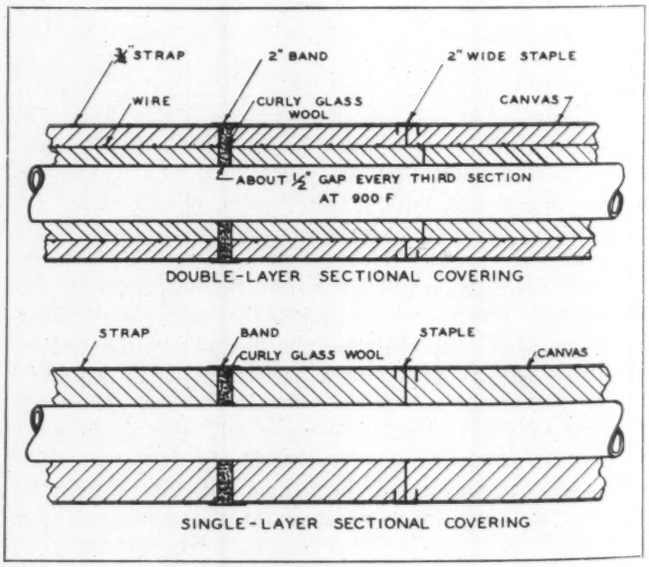
A VERY definite problem arises in insulating piping 10 in. nominal pipe size and larger operating at temperatures above 600 F. Most of the main steam piping in power plants is in this category. Inasmuch as the problems pertaining to large size piping for high temperatures are somewhat related in cause and effect, the simplest way of presenting the information is to relate some actual experiences.

High Temperature Piping

Curved segmental blocks were available for large pipes, but these were considered expensive. Also, in keeping with standardization practices within the company with which the authors are associated, flat blocks could be universally used for all large pipes whereas segmental blocks had to be stocked for each pipe size. Therefore, it had been the practice to cover large pipes with 3 in. wide flat blocks, single or double layer, of an appropriate material and thickness for the temperature involved. In this procedure, which was usually followed on pipes while at room temperature, the joints on the inner and outer layers were staggered circumferentially and longitudinally; the blocks were wired in place; asbestos insulating cement was applied on both layers; and the outside was troweled to a smooth surface, covered with canvas, and painted. The completed job was quite presentable although considerable labor was required. However, after a period in service in which shutdowns occurred, expansion and contraction of the piping caused movement in the block construction. Severe cracking in the cement and canvas resulted, particularly at the butt ends of the blocks. It was not long before the canvas, stiffened by successive coats of paint, wrinkled and cracked so badly that it became unsightly and required frequent maintenance. This problem, therefore, resolved itself into designing an installation that would be free from cracking of the canvas jacket without entailing prohibitive installed costs.

The first step taken was the investigation of materials that were commercially available in the form of sectional covering for pipes 10 in. and larger and that would prove satisfactory for service up to about 1000 F. Consideration was next directed toward a suitable design of installation for this product. The construction of three identical new boilers afforded an opportunity to compare the previous practice using flat blocks and cement on straight lengths of the 10, 12 and 14 in. superheated steam pipes from the first two boilers with subsequent installations of double layer sectional covering in similar locations on the third boiler. This large sectional covering was light and firm enough to permit handling on scaffolds and could be readily cut in the field with little dust resulting, all of which were advantageous characteristics. It was secured in place with ¾ in. wide strap steel bands appropriately spaced. Three adjacent 3 ft sections, stapled together at the circumferential joints with 2 in. wide staples, were covered with canvas as a unit to provide a continuous run of 9 ft of pipe covering. The joints between these 9 ft units as well as the joints adjacent to the block covered bends were not stapled, cemented, or canvased but after they had opened about ⅜ in. owing to the expansion of the pipe in service at 900 F, resilient curly glass wool was installed. Finally, each expansion joint was covered with a light gage metal band fitted loosely in place to permit free movement of the covering beneath. The painted ensemble is neat, durable, and economical.

Fig. 1—Assembly of sectional insulation for large high temperature piping



*Taken from a paper entitled A Study of Heat Insulation Problems in Steam Power Plants, by E. T. Cope and W. F. Kinney of The Detroit Edison Co., presented at the semi-annual meeting of the American Society of Mechanical Engineers, June, 1940. Paper published in full in *Mechanical Engineering*, June, 1940.

The principal features of this type of assembly are sketched in Fig. 1.

To state that this type of installation was entirely successful would be unduly optimistic, as some shortcomings developed which required further attention in later designs. Some sections, which fitted too tightly on the pipe, held fast when the pipe expanded in diameter and tended to move with it, causing some stapled joints to separate enough to wrinkle the canvas when the pipe cooled on being taken out of service. In general, the shortcomings of the previous practice were largely overcome.

The second stage of this program consisted of securing sectional pipe covering for these large pipes, composed of a high temperature and a low temperature material combined into a single layer, with sufficient tolerance in the inside diameter to permit from 0 to ⅛ in. clearance between the pipe and its covering, depending on the usual variations in the outside diameter of the pipe. The same method of installation was followed for this single layer covering as for the previous double layer application. The nuisance of cracked canvas was practically eliminated.

Naturally, this departure from long accepted pipe covering practices introduces many questions. For instance, is there an abnormal heat loss at the straight-through butt joints on such a single layer construction? That an abnormal heat loss does not occur at such joints is demonstrated by results of a test recently conducted by an insulation manufacturer in which three test sections of pipe covering to which had been added a temperature responsive organic indicator were heated for a considerable period on a pipe at 950 F. This conclusion is based on the fact that the isothermal lines visible in Fig. 2 pass straight across the butt joints. However, if the heat loss had been abnormal at these joints the isothermal lines would be bent. This condition is apparent at the exposed ends where the heat was rapidly dissipated into the air.

Another pertinent question concerns the necessity for the pains taken to avoid the unsightliness and maintenance expense due to torn canvas. Company policy governs the standard of appearance and durability which all construction work must meet. Thus, the request that the occurrence of wrinkled, torn canvas on insulated surfaces be eliminated or at least minimized was an important factor in this program.

It might be mentioned at this time that burning and peeling of canvas and discoloration of the paint on surfaces adjacent to hot exposed metal that protrudes through insulation is even more troublesome than the difficulty elsewhere with pipe covering jacketing. It has been found that the use of heat resisting asbestos or glass cloth to replace canvas over the area near the hot metal has been effective in eliminating this trouble and the slight added expense is well justified.

Incidentally, large pipe bends are still covered with double layer block construction, leaving an expansion joint packed with curly glass wool at both ends of each bend. In this design, the canvas is subject to excessive wrinkling and cracking and any possible improvement in technique of installation will be helpful in overcoming these difficulties.

Doubtless other improvements that can be made both in the quality of insulating materials and technique of application will make it possible to meet more of the exacting requirements in central station and industrial steam power plants as well as in numerous other industries having extensive steam piping installations.

Underground Steam Distribution Piping

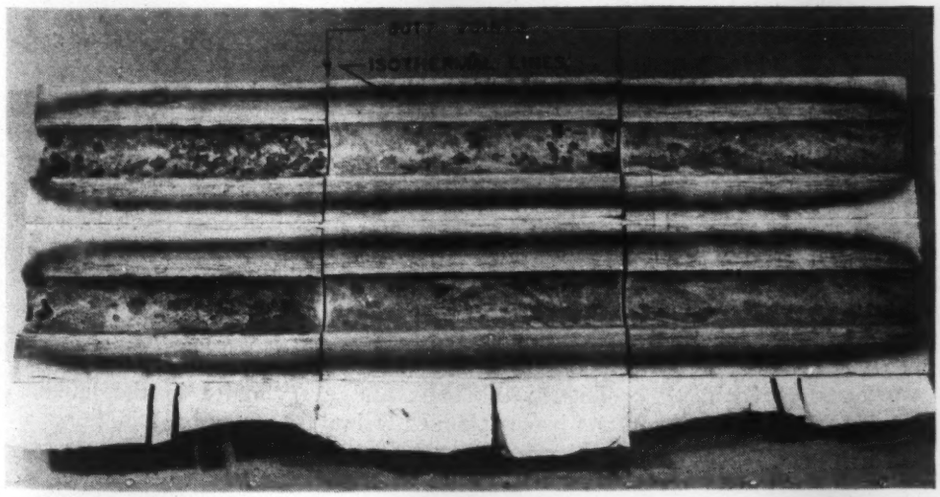
The unique problems involved in the insulation of steam and hot water pipes in underground ducts, which are particularly prevalent in heating steam distribution systems, are also included in the broad subject of this discussion. In one type of construction,[1] the pipe covering is wired in place, surrounded with a waterproof jacket, and swabbed at the joints with a waterproofing compound. The pipe is supported either on rollers in direct contact with the pipe or on saddles having lugs that extend through the insulation. In this type of construction, sealing of the outside surface of the covering is very difficult.

The problem of properly supporting the pipe and at the same time excluding flood water, which may enter the duct as a result of heavy rains, plugged sewers, or leaking water mains near by, is serious because the insulation, when it becomes water soaked, may disintegrate or rupture. In any case the insulating value of the covering is destroyed, steam condensation increases sharply and the anticipated performance is not realized.

One phase of this problem is manifested by pitting of the pipe at the point of contact between the grounded metal supports and the pipe.

Inasmuch as flood water cannot be excluded from the covering when the common methods for supporting the pipe are used, the solution to this whole problem apparently lies in the

Fig. 2—Effect of through joints in a single layer construction on the uniformity of the heat loss



[1]Illustrated in the Handbook of the National Distfrict Heating Association, 2nd ed., 1932. chap. 5, pp. 149-241.

development of either a rugged insulation that will carry the weight of the pipe on external supports without having its waterproofing membrane punctured or a design of construction in which the waterproofed insulated pipe is embedded in concrete and in which the covering fits loosely enough to permit the pipe to expand and contract freely. In any event, the installation must not be so costly as to render its use uneconomical.

Piping for Fluids Below 50 F

It should not be lost sight of that considerable piping in power plants carries cold fluids. Insulation is applied on pipes carrying cold fluids for two purposes, first, to reduce to the economic minimum the absorption of heat by the fluid, and second, to maintain the temperature of the outside surface of the insulation at a level above the dew point of the surrounding atmosphere. Occasionally a problem arises when the outside surface of the insulation is not thoroughly sealed or when metal parts of valves or hangers protrude through the covering, making possible the entrance of atmospheric water vapor. If the dew point of the atmospheric water vapor is higher than the pipe temperature, the vapor will condense on the surface of the pipe. This condensation continues as long as these atmospheric conditions persist and, in the case of organic materials, rotting occurs in a surprisingly short time. Water vapor entering at a vulnerable point may migrate and become evident elsewhere, as happens in cases in which the flaw occurs on a vertical length of pipe having an elbow below it. The condensed water vapor trickles down the pipe and saturates the insulation on the lower side of the elbow.

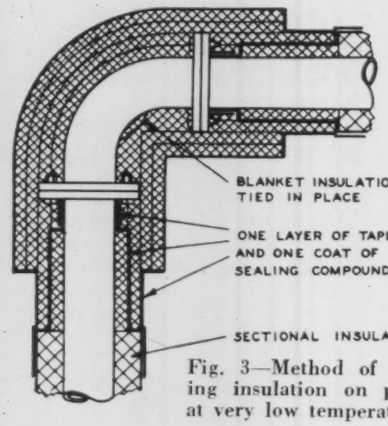


Fig. 3—Method of sealing insulation on pipes at very low temperatures

The simplest means of preventing the entrance of atmospheric water vapor into the covering is to seal completely the outside surface with an impervious film or membrane. Painting the outside surface of the jacket is the simplest and least expensive form of surface sealing and is usually sufficient for straight sections of pipe. However, the painting job must be done thoroughly so that all the surface is covered prior to putting the equipment in service. The painting should be repeated at intervals of about two years to insure a thorough seal, as the paint usually cracks with age.

The most vulnerable points of the surface are those where the shape changes, as it does at elbows, tees and valves and where hangers enter. On these irregular portions of the structure, the proper thickness of felted sheet insulation is fitted in layers, tied in place, and each layer completely sealed. The assembly is usually covered with sheeting and the outside surface is painted. Manufacturers furnish detailed specifications for various types of construction for insulation on cold pipes, which provide for the use of sealing liquids and tapes, and instructions for their proper application. A typical construction which has been developed by an industrial user for temperatures as low as —250 F, is illustrated in Fig. 3. In this, and similar types of construction, the important feature is the isolation of the vulnerable portions of the insulation by means of a vapor barrier at the junction of the sectional covering and the felted sheet insulation. This is accomplished by extending the vaporproof membrane from the outside surface of the sectional insulation across the face of the butt end and securing it onto the bare surface of the pipe. The amount of labor and material necessary for such an assembly obviously makes it a costly one.

For installations on chilled water pipes, sealing has been accomplished recently at less cost by a technique for the use of a self-vulcanizing latex emulsion on cotton sheeting as a vapor barrier.

The precautions mentioned may appear to be elaborate but experience shows that in some instances insufficient attention has been given to the proper sealing of the insulation on cold pipes.

In this survey of heat insulation problems in steam power plants, several important problems have been discussed, some definite recommendations have been made, and a few general conclusions reached. The examples cited have not been advanced as ideal ways of meeting these problems, but merely as illustrations of one company's current practice.

Outdoor Temperature a Minor Factor in Air Conditioning Load

Where in this country is air conditioning being used? Many assume that a hot summer is necessary. This is far from the case. The actual outdoor temperature seldom represents more than 25 per cent of the cooling load on an air conditioning installation. Normally 80 per cent of the load comes from radiant heat from the sun, moisture removal and internal heat loads of people, light, power uses and other heat liberating sources. As a result, it is natural that air conditioning should be used in sections of the country where large centers of population exist for in those locations internal loads within buildings pile up.—*from a paper on gas air conditioning presented by Kendall B. Castle, Jr., Rochester Gas & Electric Corp., before a conference on industrial gas sales of the American Gas Association.*

Air Conditioning a Modern Necessity

A 15 per cent higher rental charge is being commanded today in an office building because of air conditioning. This was revealed by the management of the new 21 story First National Bank and First National Bank Building, First Ave., North and 20th Sts., Birmingham, Ala.

Called the "most beautiful building of its kind in the South" when it was opened late in May, it is completely air conditioned and equipped with a centrifugal compressor of 400 ton cooling capacity, which supplies cooling to the bank and every office in the building. When it was planned to build the new bank building, air conditioning was considered as much a modern necessity as illumination and other structural features.

Radiant Heating and Cooling

How to Design a Floor Coil Heating Panel and How to Figure Pump Capacity Explained Here by F. E. Giesecke*

SUMMARY

Design of a pipe coil for a floor heating panel proceeds as for a ceiling panel as described last month, after first determining what portion of the heat delivered by the coil flows into the soil below the floor. This depends upon the location of the pipe coil and the insulation between the floor slab and the soil. Two cases are discussed here, one with the coil embedded in a concrete slab under which is a layer of sand or cinders and the other with the coil embedded in the layer of sand over which is the floor slab. . . . . Figuring the pump capacity for a panel heating system of the forced circulation hot water type is also considered this month, and Dr. Giesecke concludes with a note on the accuracy of the calculations. . . . . This is the fourth of Dr. Giesecke's articles on radiant heating and cooling and another will be in HEATING, PIPING AND AIR CONDITIONING next month

TO design a pipe coil for a floor heating panel, the calculation may proceed as described in the August HPAC for the ceiling panel after having determined what portion of the heat delivered by the coil flows into the soil below the floor. This depends upon the location of the pipe coil and upon the insulation between the floor slab and the soil. For example, the coil may be embedded in the concrete floor slab with a 6 in. layer of sand or cinders placed between the floor slab and the soil (Fig. 1) or the coil may be placed in the 6 in. layer of sand below the floor slab (Fig. 2). To calculate the quantity of heat flowing from the coil into the soil, it is necessary to know the depth at which the temperature of the soil under the floor remains constant and what that constant temperature is.

Professors L. G. Miller and C. H. Pesterfield of Michigan State College have made studies of the flow of heat into and through soils. They found, for example, that at a distance of 200 ft from a building, the soil temperatures increased from 25 F to 40 F as the depth increased from 1 to 7 ft; while at a distance of 5 ft from a building the temperature increased from 30 F to 50 F as the depth increased from 1 to 5 ft, and that under the floor of the unheated basement (temperature about 55 F) of a building, the soil temperature was practically constant at 75 F at a depth varying from 1 to 5 ft below the basement floor. It seems reasonable, therefore, to assume that the soil temperature under a heated floor panel remains constant at 70 F at a depth of 3½ ft below the floor slab, in localities having a climate not colder than that of East Lansing, Mich.

Assume that in one case (Fig. 1) the pipe coils are placed in the concrete slab 2 in. below the surface, and in the other case (Fig. 2) they are in the bed of sand 1 in. below the concrete slab; assume also that the thermal conductivities of the concrete,† sand and moist earth are, respectively, 8, 3 and 12 Btu per in. per sq ft per hr per F, and that, in both cases, the floor surface temperature is 80 F and that heat is being delivered by the floor slab to the room

*President, American Society of Heating and Ventilating Engineers. Professor Emeritus, Heating, Ventilating and Air Conditioning, Agricultural and Mechanical College of Texas.

†The thermal conductivity of concrete varies with the density and with the moisture content of the concrete. The value 8 was selected for this illustration to represent dry concrete of average density. For more accurate calculations the value of k should be taken from the ASHVE Guide for the particular concrete to be used.

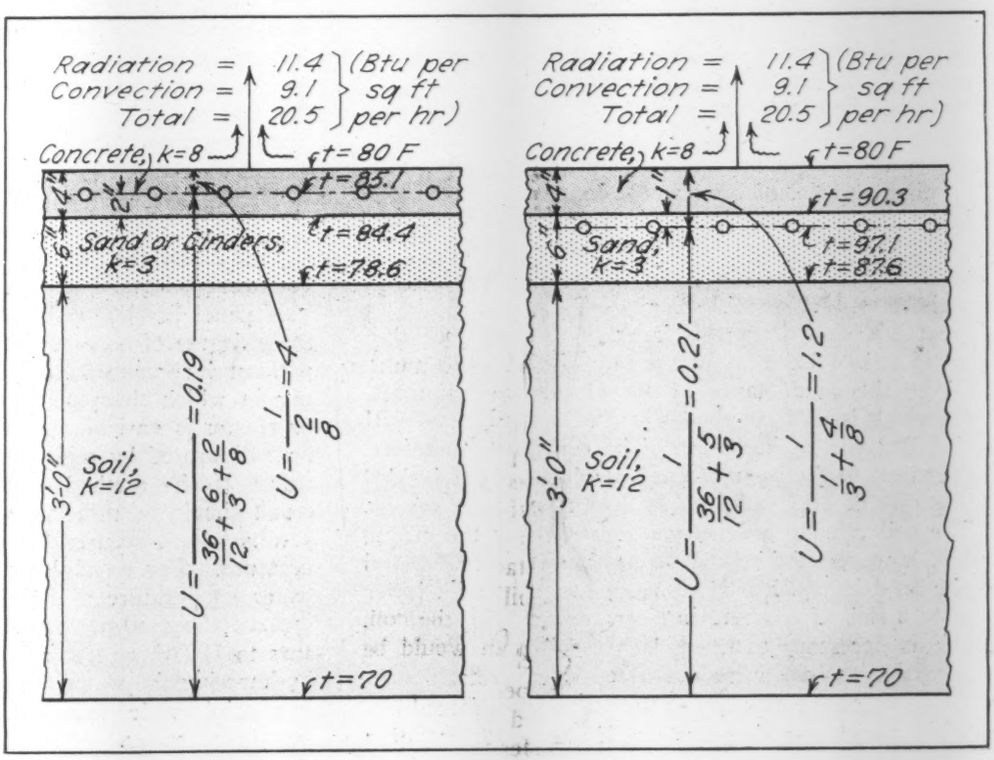


Fig. 1 (left)—This sketch represents a cross section through a floor heating coil embedded in a 4 in. concrete slab under which is a 6 in. layer of sand or cinders. Temperature at the bottom of the 3 ft of soil is assumed—on the basis of tests—to be 70 F. The text explains how to figure the amount of heat the coil must deliver in order that a total of 20.5 Btu per sq ft per hr will go to the room. . . . . Fig. 2 (right)—This is the same as Fig. 1, except the pipe coil is embedded in the layer of sand instead of in the concrete, as it is in Fig. 1

at the rate of 20.5 Btu per sq ft per hr. The flow of heat into the soil may be calculated as follows for the two cases shown:

If the coils are placed in the concrete slab (Fig. 1) and the mean temperature of the surface of the slab is 80 F, the mean temperature of the central portion of the slab (the plane in which the coils are placed) must be sufficiently higher so that the heat will flow from there to the upper surface of the slab at the rate of 20.5 Btu per sq ft per hr. Since the conductivity of the concrete is 8, the conductance of the 2 in. layer above the coils is 4, and the difference in temperature between the two planes must be 20.5 divided by 4 or 5.1 deg; hence the temperature of the central plane must be 80 + 5.1 or 85.1 F, as shown.

To find the rate of heat flow from the center of the concrete slab having a temperature of 85.1 F to the layer of soil 44 in. below, and having a temperature of 70 F, it is necessary to find the conductance of the 44 in. layer of materials consisting of 2 in. of concrete, 6 in. of sand, and 36 in. of soil. The respective conductances of these three layers are 8/2, 3/6, and 12/36; the respective resistances are therefore ¼, 2 and 3; the total resistance is 5.25 and the total conductance is 0.19, as shown in Fig. 1. The flow of heat into the soil is therefore at the rate of 0.19 (85.1 — 70) or 2.9 Btu and the coils must deliver heat to the concrete slab at the rate of 20.5 + 2.9 or 23.4 Btu per sq ft per hr. The size of the coil may be designed as explained last month for the ceiling panel.

The calculation for the flow of heat in the second case (Fig. 2) is similar to that just explained.

To find the mean temperature of the layer of sand in which the coils are placed (Fig. 2) it is necessary to know the conductance of the 5 in. layer of materials consisting of 1 in. of sand and 4 in. of concrete. It is 1.2, as shown in Fig. 2. The temperature difference between the two planes is therefore 20.5 divided by 1.2 or 17.1 deg and the mean temperature of the layer of sand is 80 + 17.1 or 97.1 F.

Heat will flow from this layer of sand to the 70 F layer of soil 41 in. away at the rate of 97.1 — 70 multiplied by the conductance of the 41 in. layer of materials, which is 0.21, as shown in Fig. 2, or 27.1 × 0.21 or 5.7 Btu per sq ft per hr. The coil must, therefore, deliver heat to the layer of sand in which it is embedded at the rate of 20.5 + 5.7 or 26.2 Btu per sq ft per hr.

The coil can be designed as described for the ceiling panel; however, the rate of heat transfer from the coil to the sand in which it is embedded is, no doubt, lower than to a slab of concrete in close contact with the coil, and it is necessary to use a larger coil than would be necessary if the coil were embedded in concrete.

To calculate the capacity of the pump for a forced circulation panel warming system, if the heat loss of a building is 120,000 Btu per hr and the temperature drop through the coils is 20 deg, the pump must deliver 120,000/20 or 6000 lb per hr of water or about 12 gpm. However, if the water cools only 10 deg in flowing through the coil, the pump must deliver about 24 gpm. The friction head (that is, the head against which the pump must operate) is calculated like it is with any other forced hot water heating system. For example, in the system shown in Fig. 3, the total friction head consists of the partial heads in the following five sections:

1) In the flow main from the boiler to point 2.

2) In the flow riser from point 2 to point 3.

3) From the flow riser at point 3 through the coil to the return riser at point 4.

4) In the return riser from point 4 to the return main at point 5.

5) In the return main from point 5 through the circulating pump and through the boiler to the point of beginning.

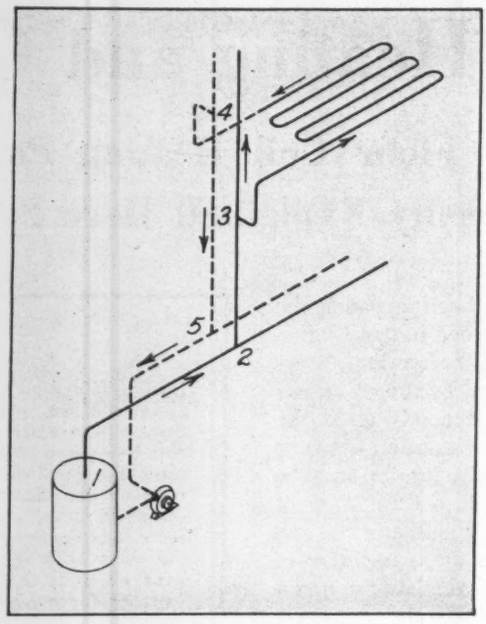


Fig. 3—Friction head against which the pump must operate is calculated like it is with any other forced hot water heating system. In this case, the total friction head is made up of the partial heads in sections *1-2, 2-3, 3-4, 4-5* and *5-1*

To calculate the loss of head in the coil, it is only necessary to treat it as a section of a circuit consisting of a certain number of feet of pipe and a certain number of tees and ells; in doing this, each return bend may be placed equal to one elbow—this is not quite accurate but the resulting error is on the side of safety. Having found the number of feet of pipe and the number of elbow equivalents in the coil circuit, its friction head is found in the usual way. Since the friction head in pipes and fittings varies almost as the square of the velocity, it is evident that the power required to force the water through a panel warming system is almost eight times as great when the water cools only 10 deg in flowing through the coil as when it cools 20 deg, because the pump must circulate twice as much water against a head almost four times as high.

The coils should whenever possible be connected to the risers so that the water flows upward through the coils in order that any air which may be trapped in the coils can escape in the direction of water flow.

A panel heating system cannot be designed with the same degree of accuracy as an ordinary radiator system without very complicated calculations, because the manner in which the pipe coils are covered with concrete or plaster is variable and also because the quantities of heat dissipated by radiation and by convection are variable. If the method suggested above is applied, the result should be sufficiently accurate so that satisfactory results can be secured by a variation in the water temperature. For example, if a system is designed for a water temperature of 100 F, its heat output can be increased about 30 per cent by raising the water temperature to 110 F, or it can be decreased about 30 per cent by lowering the water temperature to 90 F. This range is certainly wide enough to protect against probable design inaccuracies.

Heating, Ventilating and Air Conditioning on Shipboard

S. S. *America*, largest and finest ship ever built in this country, proceeds up New York harbor to her pier on July 29. New Yorkers gave the 35,440 ton luxury liner an enthusiastic welcome. Built for trans-Atlantic travel, she is inaugurating a fortnightly West Indies service because of the war

More Information About Marine Applications—an Active Field These Days—Is Presented Here by John H. Clarke*

TYPES of exhaust systems used on shipboard vary, depending upon numerous factors. Usually staterooms and similar spaces exhaust naturally into passageways through door louvers. Where passageways are below deck it is customary to provide mechanical exhaust. All toilet and shower spaces are provided with mechanical exhaust while natural supply is obtained through door louvers. Particular care must be taken in arranging the exhaust from the air cooled and adjoining spaces so that the refrigeration equipment is not overburdened by decreased recirculation in the air cooled spaces, and by too great a temperature differential between the air cooled and the adjacent spaces. To do this, the exhausting of cooled air directly to the outside should be avoided wherever possible. A gradual change in air temperature between the warm and cool spaces should be obtained by exhausting through the warmer passageways or public spaces, thus minimizing infiltration of warm air to the cooled spaces. It is particularly important that short circuits between the supply outlets and the exhaust inlets be avoided.

All spaces which house heat generating equipment and which cannot be effectively ventilated by natural exhaust to the atmosphere are provided with mechanical exhaust ventilation. In galleys, pantries, bars, smoking rooms and similar spaces, excess mechanical exhaust is provided in order to prevent odors and smoke from entering adjoining spaces. The excess exhaust is taken directly from the outside through louvers, air ports, doors, etc., or it is drawn from the adjoining spaces. Exhaust hoods are provided over all large sources of heat such as cooking ranges, steam kettles, electric grills and ovens. Hospital spaces are provided with mechanical supply and exhaust to give a four minute air change. Galley, toilet and shower, passage and hospital exhaust systems must each be independent although several passageways or several toilet and shower spaces may be exhausted by the same system.

Proper Control Important Factor

One of the most important factors of any ventilation or air conditioning system is the proper installation and location of control valves. This factor has been much more carefully watched in air conditioning since the in-

*Technical Div., United States Maritime Commission.

SUMMARY

Great strides are being made today in the application of heating, ventilating and air conditioning to our merchant ships. Old rule-of-thumb methods are rapidly passing and naval architects and marine engineers are aware of the importance of good design, equipment and insulation and proper adaptation of the various systems. Probably one of the most outstanding features of the Maritime Commission's present program—purpose of which is to provide about 500 new ships over a period of 10 years—is the emphasis placed upon proper ventilation, refrigeration and humidity control for cargo holds . . . This article explains the types of exhaust systems used on shipboard, and follows with a section on proper installation and location of control valves—one of the most important factors in the success of any ventilation or air conditioning layout. Several sketches show different methods of thermostat location, and the accompanying text explains their uses and advantages. Machinery ventilation is then treated, and major attention is given to ventilation of cargo holds, with diagrams and an explanation of a recently devised system for controlling the humidity of the air in these holds . . . A third article on shipboard heating, ventilating and air conditioning will discuss further details of marine installations; an article in the August HPAC was devoted to the Maritime Commission's program, the problems peculiar to marine work, and types of systems used on shipboard

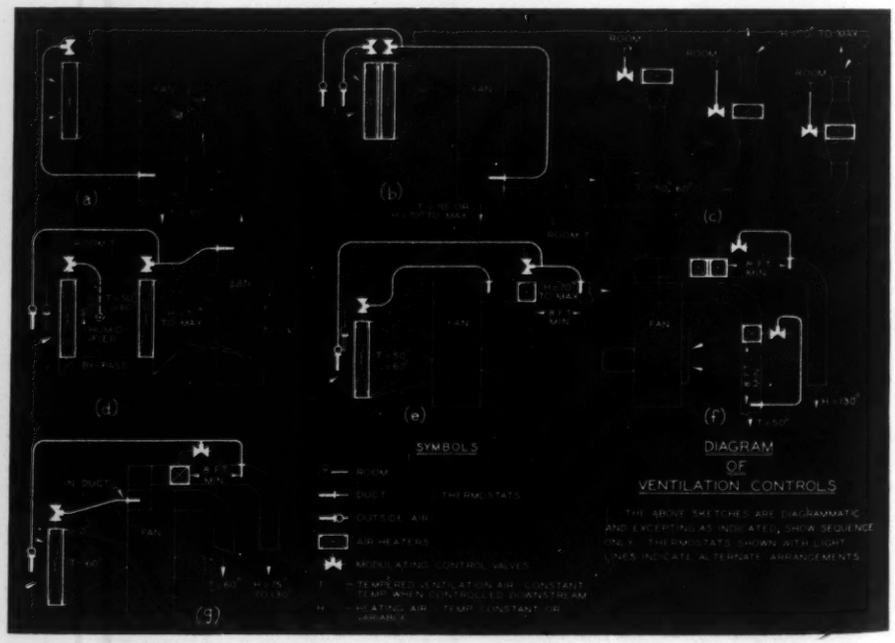
dustry is comparatively new and its designers are not bound by tradition; as a result the systems are well designed. Equally important is the custom of manufacturers of this equipment to coördinate all of the items that go into the system and to assume responsibility for the proper operation of the installation. In ventilation work, unfortunately, this is not true. The various items are furnished by separate manufacturers, none of whom can guarantee proper operation of his equipment as he has no control of the other equipment supplied. The Maritime Commission is trying to improve this situation.

The use of manual controls is definitely being eliminated for all future ships because such control is impractical even for small cargo ships. There have been many complaints by the ship personnel of overheating, blasts of hot and cold air, poor control valves, and the freezing of heaters. Part of this has been due to the use of manual control and part of it due to unbalanced heating, as explained last month. Another factor is the continued tendency to oversize equipment, and this is one thing it is very important to avoid. Heaters that are oversize are susceptible to freezing, are apt to cause stratification of the air, and weigh and cost more. Stratification in the vicinity of a thermostat upsets the control, as the thermostat will be subjected to an air temperature that is neither constant nor a true average for the duct. Control valves that are oversized are simply incapable of the operation for which they are intended. What generally happens is that one person makes an initial calculation of the heat requirements and adds 10 or 15 per cent as a factor of safety. Someone else gets this estimate and adds another factor just to make sure the equipment will have sufficient capacity. The size finally selected is that which satisfies the last estimate. It is unfortunate that such is the case. Actually no factor of safety should be added to the capacities of any of this equipment except a small amount intelligently added to satisfy expected variations in operating conditions. The equipment finally selected should be that which most nearly meets the requirements for the specific operating conditions, and this does not necessarily mean the *next largest size*. As it is now, it is not uncommon to find heaters and control valves as much as 50 or 100 per cent oversize, and still expected to operate properly.

Location and Setting of Thermostats

The location and setting of the thermostats have also been greatly misunderstood. At present it is specified that any thermostat which follows a heater must be at least 8 ft downstream or else following a fan. In any number of cases this rule has been disregarded in the past and thermostats have been placed within a few feet of the heaters. In one case (Fig. 1 *d*) a room thermostat was installed about 2 ft from the heater and halfway down the side of the duct. The preheater was also greatly oversized so it can be easily seen that the control valve never had a chance to reach equilibrium and to do its job properly. The diagrams in Fig. 1 illustrate some of the control systems that have been installed on various ships. Diagram *a* is the preferred arrangement for tempered ventilation air, *e* is preferred for central heating systems, and *g* is preferred for dual duct systems. Diagram *c* represents the control for a unit system. At this point it should be made clear that all pre-

Fig. 1—Some of the control systems that have been installed on various ships. Their uses and features are explained in the text



heaters should be of non-freezing design wherever they are apt to be exposed to temperatures below freezing and when at this point, the control valve is not essentially wide open so as to admit the full amount of steam to the heater. This would mean that the preheater for *b* would be the only one which would not need to be of this special design, and even then the thermostat which precedes the heater would have to be set to be wide open below 32 F.

As just mentioned, *a* shows the arrangement for ventilation air. Sketch *b* can be used either for ventilation or central heating depending upon the controls used. For central heating the preheater control is placed before the heater and set to open the valve wide open as the outside air temperature drops from 35 to 32 F. Under these circumstances the preheater must be carefully sized to prevent overheating. The two heaters together make a compact arrangement but this does not provide as good control as is afforded by other systems. The reheater for *b* is controlled similarly to *a* for ventilation air, but where it is used for central heating a two bulb valve is used and set so that the duct thermostat keeps

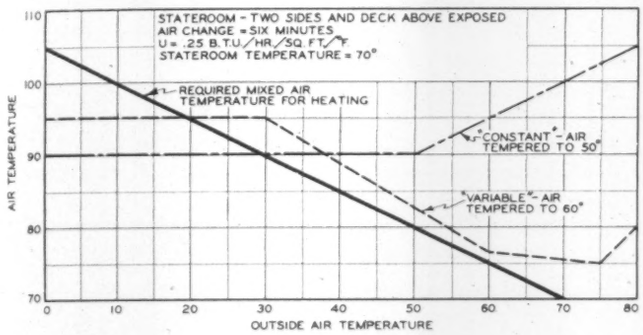


Fig. 2—Comparison of mixed air temperatures for a "constant temperature" and a "variable temperature" dual duct ventilation heating system. All outlet dampers wide open. The heavy line represents the final air temperature that is necessary to heat the compartments to 70 F under the specified conditions. The amount by which the air mixture temperatures are above or below this line represents the degree to which damper control must be used in order that the space will be properly heated

the temperature from fluctuating due to local conditions, and the compensating bulb in the outside air intake varies the duct temperature from 70 F to the maximum temperature (as estimated, and usually about 100 F) as the outside air temperatures drop from 70 to 0 F. Sketch *c* represents the type of control for unit heating with preheated air and terminal heaters.

Sketch *d* represents another arrangement that is often used for either ventilation air or central heating. The controls and arrangement are similar in application to *b* except that unfortunately there have been cases, as previously stated, where the preheater thermostat has been placed between the heaters with poor control resulting. The distance between the two heaters is about 3 ft. On one of these installations steam humidification is supplied through a perforated pipe with the quantity of steam controlled by an orifice. The results as far as humidifying are concerned are very satisfactory. A bypass with a manually controlled damper is placed below the heaters so that more air may be circulated for ventilation during the summer.

Sketch *e* represents a good control design for central heating. It is compact and yet it affords good positions for the thermostats. Both thermostats being downstream, there should be little fluctuation of temperature. As an alternate to the two bulb valve a single room thermostat can be used to regulate the temperature. This thermostat should be placed either in a protected passageway or other representative space such as a dining saloon (which is also a lounge room for ship's officers and crew). In some cases these room thermostats have been placed in individual staterooms with disastrous results. This thermostat controls the whole heating system, of course, and any time the stateroom occupant opened his window or closed his ventilation damper, the whole system was upset, resulting in overheating in the other compartments.

Sketches *f* and *g* represent control arrangements for the dual duct system. Since regulation must be downstream for this system in order to maintain constant temperatures, the heaters exposed to the outside air should be protected against freezing by using the non-freeze type of heater, although they have not always been supplied. Return bend heaters are particularly vulnerable under these circumstances. This would mean that there should be two non-freeze heaters for *f* but only one for *g*. It will be noted that a two bulb control valve is shown for the reheater in *g*. This is used to vary the hot air temperature from 75 to 130 F as the outside air temperature drops from 75 to 30 F. A single bulb and constant temperature as indicated in *f* have usually been supplied in the past with the result that the staterooms are likely to be overheated in mild weather, and in addition, all the reheaters must be shut down manually in hot weather.

For ships operating on routes where the temperature changes rapidly due to the various climate zones (such as the South American run), and where there are a large number of ventilation systems, this is quite a burden to place on the deck engineers. A clearer picture of this situation is given by Fig. 2, which shows the comparison between a constant temperature and variable temperature dual duct system with the dampers on both the hot and cool ducts wide open. The resulting mixed air temperatures are then plotted against the outside air temperature. The heavy line represents the final air temperature that is necessary to heat the compartments to 70 F under the specified conditions. The amount by which the air mixture temperatures are above or below this line represents the degree to which damper control must be used in order properly to heat the space. Usually the hot duct and the cool duct each carry 50 per cent of the air supply to the outlet (duct capacity), but where the constant temperature is used, orifice plates are sometimes inserted in the ducts in order to supply an excess of cool air so as to decrease the possibility of overheating. The effect of this would be to drop the curve for the air mixture (Fig. 2) but the sharp rise at the higher outside air temperatures would still exist.

Machinery Ventilation

For machinery ventilation there are several different methods of estimating the amount of air to be supplied. One that has been quite popular is to supply air at a one to four minute air change rate. But in the case of a ship

like the *America,* where about 300,000 cfm is supplied in the machinery spaces, it is evident that the difference between a one minute change and a four minute change is considerable. Actually the only real solution is to base the ventilation on the heat liberation for the power plant involved and design for a specific maximum temperature rise over ambient. The heat liberation will depend upon the amount of insulation used and the resultant surface temperatures of the equipment, as well as upon the concentration and arrangement of equipment. As another important factor, the air must be properly distributed to be effective. Hot air rises, of course, and the part of the engine spaces below the water line are partially cooled by the sea water. Consequently a much higher proportion of air should be supplied to the upper working and control platforms than to the lower working levels.

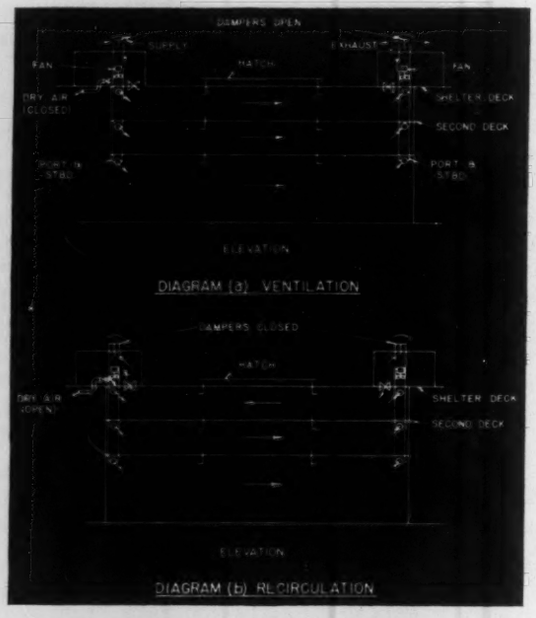


Fig. 3—Ventilation system for controlling humidity in cargo holds. When the outside atmosphere has sufficiently low humidity, it may be circulated in large volumes through the holds as indicated in *a*. When the dewpoint outside rises above that in the holds or above the temperatures expected to be encountered within the next few days or at the port of discharge, outside air is excluded by setting up the recirculating system as shown at *b*. The humidity and dewpoint are reduced by injecting into the recirculating air stream very dry air from the specially designed silica gel dehumidification equipment as diagrammed in Fig. 4

The supply air is usually furnished through direct duct, scoop or universal outlets to the various platforms just mentioned. Outlets above hot equipment are generally avoided. In boiler rooms, the exhaust is usually removed through the intakes to the forced draft blowers. In other machinery spaces natural exhaust is provided through casings or exhaust cowls. Where mechanical exhaust is installed its purpose is to remove heat from "hot spots." When this is done the volume of the exhaust is often about one-fifth of the supply. On the *America,* while 100,000 cfm is supplied in the engine room, 50,000 cfm is exhausted from the generator flats, switchboard and operating platform. On diesel ships where the machinery space may become too cold when the main engines are shut down, wall type radiators (or in a few cases, unit heaters) are supplied to supplement the ventilation system.

Ventilation for Cargo Holds

As mentioned last month, practically all new ships are now supplied with mechanical ventilation for the cargo holds. Ordinary dry cargo holds are furnished with about two or three changes of outside air per hour. In all refrigerated cargo holds independent blowers furnish about three changes per hour of outside air. For refrigerated holds arranged for fresh fruits and vegetables at 35 to 55 F, the air is recirculated at the rate of one and one-half changes per minute. For these holds the outside air is supplied to the diffuser compartments or boxes and preferably the duct is extended so as to discharge at the diffuser intake. The recirculated air is drawn into the diffuser compartment through a grille and the diffuser cooling coils and is then blown back into the hold through ducts distributed throughout that space. For the warmer compartments heating coils are provided in the diffuser boxes on a bypass so that the air may be heated if necessary when the outside air drops below the specified hold temperature. The air change rates indicated above are figured with the holds empty.

Recently an entirely new system has been devised for cargo ventilation which completely controls the humidity of the air in the cargo holds. The principal object is to prevent "sweat damage" from condensation of moisture vapor on the cargo itself, or on the ship's structure. This is done by keeping the moisture content of the air below saturation at whatever temperature it may fall to locally. In addition, the humidity is kept high or low depending upon the requirements of the cargo carried.

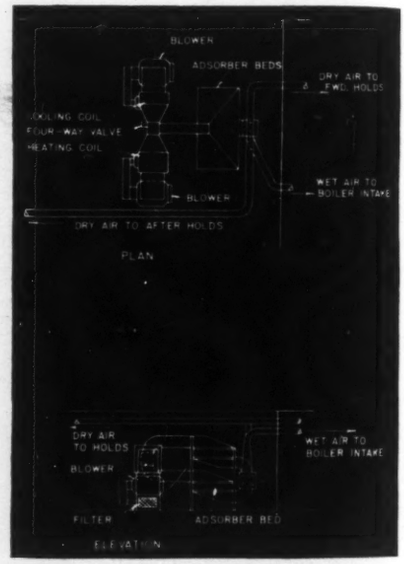


Fig. 4 — Dehumidification equipment for supplying very dry air when the system of Fig. 3 is operated recirculating. The dehumidification equipment consists of beds of silica gel used alternately for adsorption and reactivation

No attempt is made to heat or cool the holds as the dewpoint of the air is independent of temperature changes above it, and depends entirely upon moisture content. It would also be impractical to attempt artificial heating or cooling of the holds as the system is designed for uninsulated holds. Warming of the cold cargo is accomplished, however, by the vigorous recirculation of air in each hold—thus borrowing heat from hot decks and warm ocean currents. This is often desirable as "cargo conditioning," so that cargoes can be discharged in a wet, humid climate such as Houston, Texas, where the dewpoint is high. Unless

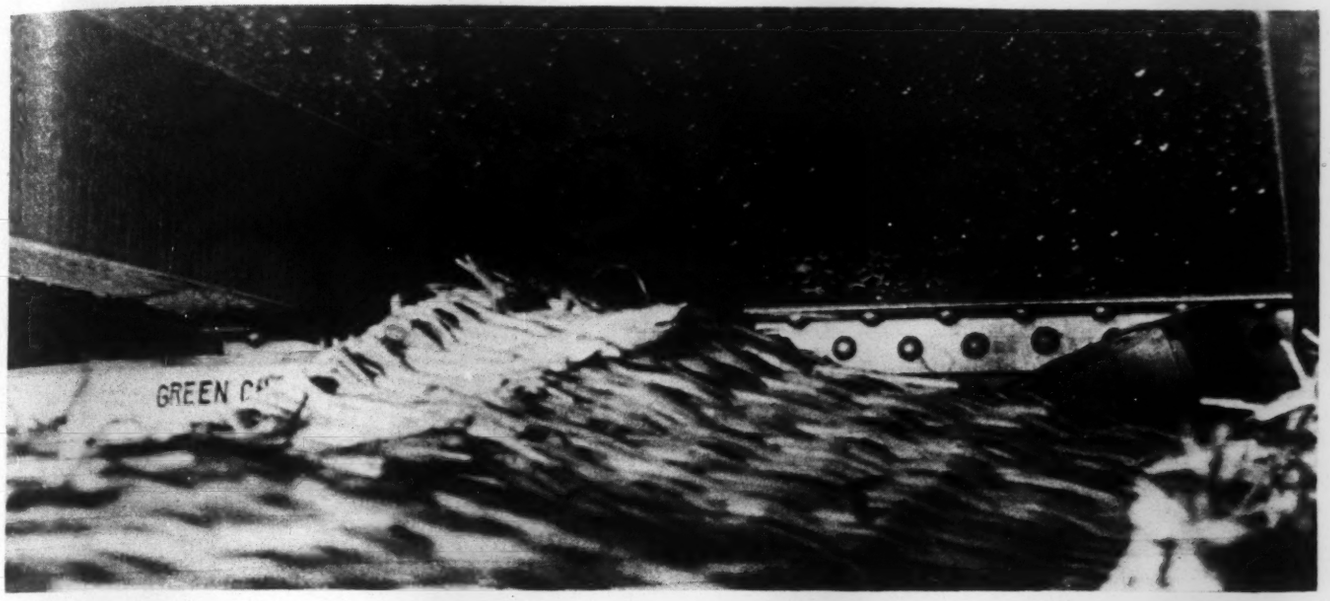


Photo courtesy Cargocaire Corp.

Fig. 5—This picture indicates the importance of humidity control in cargo holds. It shows the underside of the deck above in a loaded hold. Note sweat or condensation dripping on the cargo. The mats shown are intended to protect the cargo from the sweat

warmed, the cargo may be dry in the hold but start to sweat in the slings on the way out.

When the outside atmosphere has a sufficiently low humidity or dewpoint, it may be circulated in large volumes through the holds by means of a supply fan, an exhaust fan, and suitable duct work as shown in Fig. *3a*. When the dewpoint outside rises above that in the holds or above the temperatures expected to be encountered within the next few days or at the port of discharge, it will be necessary to exclude outside air and to use a source of drier air than obtainable from nature at that time. Excluding outside air is accomplished by closing all ventilating mushroom heads and setting up a recirculating system as shown in Fig. *3b*. It will be noted that the upper 'tween deck acts as the return duct. This large recirculating stream ventilates remote spots and insures care of cargo in remote spaces.

The humidity and dewpoint are reduced by injecting into the recirculating stream, diagram *b*, very dry air brought from specially designed dehumidification equipment near the engine room. This equipment, Fig. 4, consists of beds of silica gel which are used alternately for adsorption and reactivation. Air to be dehumidified is forced by a positive displacement blower through cooling coils to the adsorbing bed and on to the holds under treatment via suitable valves and ducts. At the same time, air is blown through heating coils to the other bed to reactivate it for adsorption. This air is led to the boiler intake, if possible, and thence overboard.

As mentioned, the ship's officers change to recirculation and dehumidification when air conditions within the hold and in the atmosphere require it. This is determined by reading continuous records of relative humidity and temperatures from which the dewpoint can be easily determined. Each hold is equipped with sampling pipes to each deck which lead air to a recorder cabinet in a resistor house which contains the recirculating fans and controls. The condition of the outside air is determined by a similar cabinet situated in the chart house.

This system has much merit and will undoubtedly find a wide field of application for cargoes which are not inert and which may be damaged by moisture. Important results have also been obtained in reduction of corrosion and maintenance of the ship's structure through dry conditions. Some ships now in service show distinctly the difference in the condition of the structure of holds regularly treated by dehumidification and those which are exposed to the usual sweating conditions encountered at sea. Fig. 5 shows a typical case of condensation on the deck overhead in an untreated hold.

[*A third article on ship heating, ventilating and air conditioning will cover details of duct design and installation, types of fan, filter, heating and cooling, and humidifying equipment used, insulation, piping, etc. An article in the August HPAC was devoted to the Maritime Commission program, the problems peculiar to marine work, and types of ventilation and air conditioning systems used on shipboard.*]

MARITIME COMMISSION PROGRAM AIDS NATIONAL DEFENSE

A nation's merchant marine is a vital element in its national defense plan, for transportation of essential materials from sources of supply throughout the world must be assured and the fighting navy requires auxiliary ships of numerous types. Some of the ships to be built under the Maritime Commission program are understood to be designed for conversion to aircraft carriers in time of war. . . . . While the Commission's program was initiated in 1936 when Congress passed the Merchant Marine Act, it has become of greatly increased importance within recent months because of the emphasis on national defense and re-armament. The purpose of the program is to provide about 500 new ships over a period of 10 years to replace our ever-growing number of over-age ships, and at the same time to bring about a practical coördination of replacement and retirement in order to stabilize the shipbuilding industry of the U. S. It can be seen that the latter phase of the program is also a most important contribution to U. S. defense, for in modern warfare—as never before—the industries of a nation are an essential line of its defense.

—The Editor.

Turbine Driven Centrifugal Machine Improves the Plant's Heat Balance

How Centrifugal Refrigeration Compressors May Be Used to Promote Air Conditioning Economy...By W. S. Bodinus*

SUMMARY

Where exhaust or high pressure steam is available, the turbine driven centrifugal refrigeration machine may be utilized to make the refrigerating unit an element in the complete heat balance of the plant. Its by-product—refrigeration—can be used for cold storage work, process cooling, industrial air conditioning or comfort cooling. The compressor may be driven by a steam turbine of the low pressure, high pressure or mixed pressure type. . . . A brewery, for example, may have boilers operating at 450 lb pressure and require 50 lb steam for process work; in this case, a turbine operating at 450 lb initial pressure and exhausting at 50 lb can act as the reducing valve. . . . In the private electric generating plant exhausting to atmosphere the exhaust steam can be used for heating in winter, and in summer can be used for cooling. . . . Where the power or process steam requirement is quite variable, or process steam is required at irregular intervals, a mixed pressure or bleeder type turbine may be used. In this way, full use can be made of all available exhaust steam and at the same time the necessary refrigerating effect can be obtained automatically. . . . In certain instances where the centrifugal machine has been fitted into a heat balance, operating economies amounting to thousands of dollars have been achieved

IN an industrial plant where there is an abundance of steam (or—for that matter—any place where exhaust or high pressure steam is available) the centrifugal refrigeration compressor driven by a steam turbine gives flexibility in and economy of operation. The refrigerating unit simply becomes an element in the complete heat balance of the plant and its byproduct, refrigeration, can be utilized for cold storage work, process cooling, industrial air conditioning or comfort cooling. The compressor may be driven by a steam turbine of the high pressure, low pressure or mixed pressure type.

For example, a brewery may require a considerable quantity of steam at 50 lb pressure with boilers operating at 450 lb pressure; high pressure is supplied to electrical generating units, and pressure at 50 lb is obtained through a pressure reducing valve. Instead of the pressure reducing valve a centrifugal compressor with a turbine drive at 450 lb initial pressure exhausting at 50 lb might be used. This 50 lb steam is in a saturated condition ready to condense efficiently in hot water heaters, brew kettle, mash tubs or for other processes. One of the ideal features of the 50 lb exhaust steam is the fact that it is free from oil or other contamination since all lubricated parts, stuffing boxes, etc., are external on the turbine. The steam consumption would run 30 to 35 lb per hr per ton of refrigeration.

Some installations require operation of a large power boiler in summer at low ratings, making firing difficult and operation inefficient. Where the centrifugal is added to such a plant, the steam is supplied at boiler pressure and exhausted at 26 to 28 in. of vacuum, producing full refrigerating capacity at the low consumption of from 12 to 18 lb of steam per ton of refrigeration. The quantity of condenser water required for the refrigeration machine is the normal amount and this quantity has in almost every instance proved quite ample for the steam condenser service. Since the plant operation requires normal service and fuel handling the cost of power is hardly any more than the additional fuel cost.

In the private electric generating plant exhausting to atmosphere, the exhaust steam at 1 to 5 lb pressure can be utilized for heating in winter and the heat balance is quite satisfactory. In summer, however, this steam is wasted to atmosphere. Where this is the case and a centrifugal is added, the exhaust steam at 5 lb pressure may be supplied to the turbine and exhausted from it at 26 or 28 in. of vacuum. The exhaust steam consumption for plants of this type is 24 to 28 lb of steam per ton of refrigeration produced. The condensate is also recovered, thus reducing maintenance, water treatment cost, etc.

Where the power steam requirement is quite variable or where process steam may be required at irregular intervals, then a mixed pressure type turbine or bleeder type turbine may be used. This type of centrifugal compressor drive has the ability to take in or give out steam at any desired intermediate pressure, at any variable quantity, and it does it automatically; the balance of the steam goes on down to condensing. Thus if a group of steam engines exhausts at 10 lb for process work during the day and the quantity given up by the engines is insufficient, then the turbine on the centrifugal refrigerating machine would make up the deficiency by exhausting the necessary steam at 10 lb. If at night the process load is small and the engines deliver an excess, the centrifugal unit would take in the excess steam given up by the engines at 10 lb and carry it on down to 26 or 28 in. of vacuum. Full use could thus be made of all exhaust and at the same time the necessary refrigeration effect could be obtained automatically.

In certain instances where the centrifugal machine has been fitted into a heat balance, operating economies amounting to thousands of dollars a year can be observed.

*Carrier Corp.

Piping Does Double Duty

Same Circuits Serve Twelve Zones of Department Store Air Conditioning System Summer and Winter

By David E. Alton*

AN interesting air conditioning system utilizing an unusual piping layout serves the Meyer Bros. department store at Paterson, N. J. This installation is one of the largest in the state, 265 tons in cooling capacity, and was designed for year 'round operation. Its distinguishing feature is its unitary zone design, which consists of independent zones receiving chilled and heated water from a central circulating plant. In this way the entire store, 126,000 sq ft in all, is divided into 12 zones each equipped with its own fans, coils, controls and duct system.

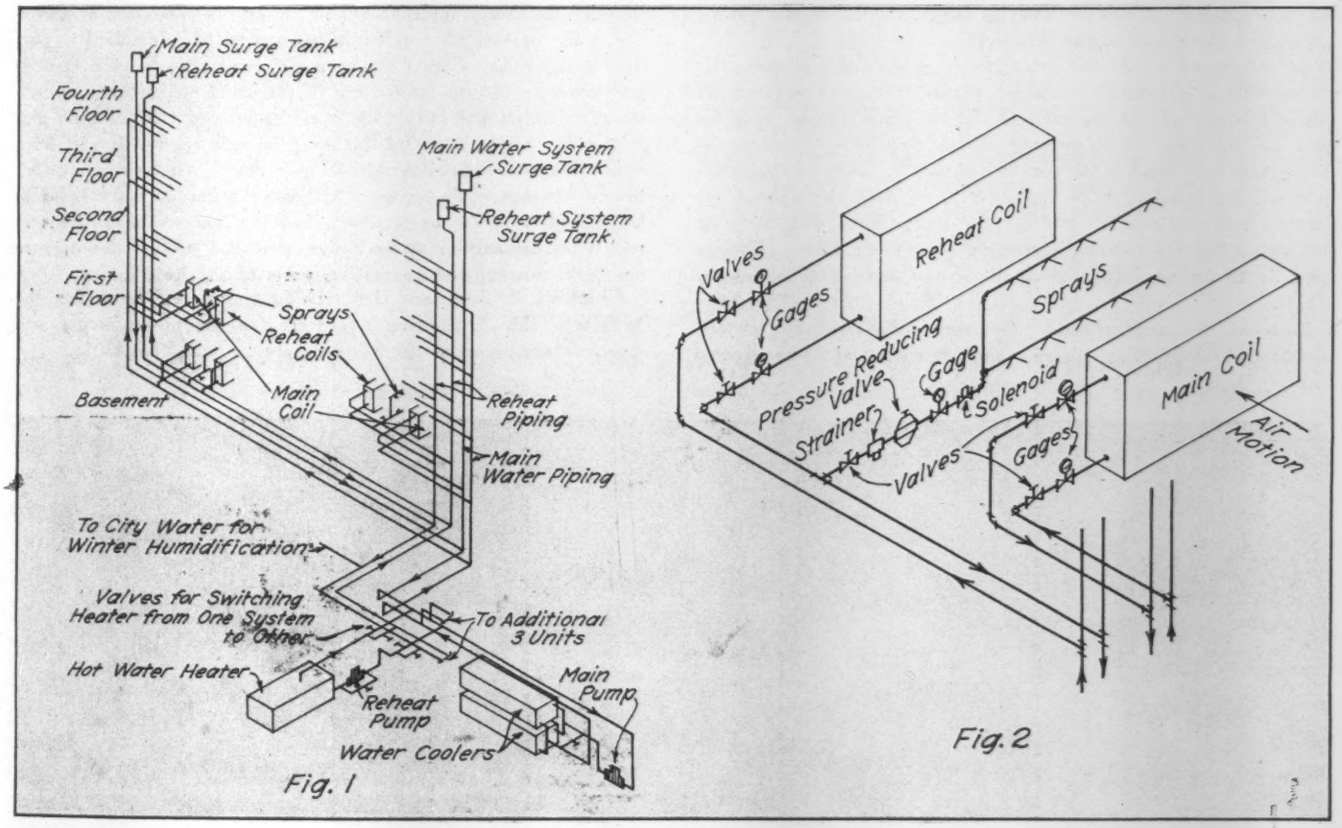
Although the zones are otherwise independent of each other they are all dependent upon the circulation of the proper quantity and temperature of water through their coils and sprays for satisfactory performance. For this reason a great deal of thought and time was spent in the design of the two circulating systems. These two systems are called the main water system and the reheat system. The purpose of the first is to feed chilled or heated water to the main water coil in each zone system, and the purpose of the second is to feed heated water to the reheat coil, or city water to the sprays in each zone. The water in each of the two circulating systems is heated or cooled as required within the machine room,

*Montgomery Engineering Co.

SUMMARY

An unusual piping layout is used in connection with the 265 ton air conditioning system serving the Meyer Bros. department store in Paterson, N. J. The store is divided into 12 air conditioning zones, each with its own fans, coils, humidifying sprays, controls and ducts. . . . The main water coil of each of these assemblies is supplied with chilled or heated water from the machine room, the reheat coils are supplied with heated water, and the humidifying sprays are furnished with city water. Two piping systems are used for this, the main water piping and the reheat piping. . . . Since demands for dehumidification and heating do not occur at the same time, it was possible to use the same heat interchanger for both services. Also, the demand for reheating does not occur simultaneously with the need for humidification, so the return side of the reheat piping is utilized as the water feed line for the sprays in each of the 12 separate zones

Fig. 1 (left)—General arrangement of the piping for supplying chilled or heated water to the main coil of each of the 12 air conditioning assemblies and for supplying heated water to their reheat coils. The return side of the reheat piping system is used as the feed line to the humidifying sprays in winter.... Fig. 2 (right)—Detail showing typical piping connections at each of the coil units, with the necessary valves, gages and other accessories to assure proper balancing of the system and operation



where the compressors, heaters, coolers and pumps are situated. From this point it is then circulated by the two piping systems to the coils in each zone.

In designing the piping systems, every effort was made toward an economical, efficient as well as complete layout. The total quantities of water circulated are 800 gpm in the main system, and 200 gpm in the reheat system. The water velocities used throughout are 6 fps, and upon that basis a 15 hp pump for the main line and a 5 hp pump for the reheat line both operating at a 50 ft head were chosen.

As previously noted, the main water coil in each zone is used for cooling as well as heating by alternately circulating chilled or heated water through it. For this reason suitable valves and interconnecting piping have been installed between the heat interchanger and chilled water coolers to permit either to be put into the main water circuit for heating or cooling the water. Since the demands for dehumidification and heating do not occur at the same time, it was possible to use the same heat interchanger for both water systems. This being possible, the necessary interconnecting piping and valves were installed to switch the heat interchanger from one piping system to the other.

In a similar way, since the demand for reheating does not occur simultaneously with the need for humidification, further economies in piping were accomplished. When there is a demand for humidification the reheat circuit is shut down, and the return side of this piping circuit is utilized as a water feed line to the sprays in each zone. The method in which this is done is shown in Fig. 2, where a typical coil and spray section is illustrated. All that has to be done is to shut the valves leading to the reheat coils, open the valves to the sprays, and in the machine room open up the return side of the reheat system to the city water main.

The inlet and outlet gages shown for both the reheat as well as the main coils are an exceedingly important feature of the system. They are the means by which pressure drop through the coils may be arrived at and the water quantities calculated. This is very important for the proper balancing of the system. The installation of these gages is shown in Fig. 2. Also illustrated in Fig. 2 is the spray control assembly consisting of the following: an electric solenoid valve for controlling the operation of the sprays; a water line strainer to prevent clogging of the nozzles; a pressure reducing valve for regulating the operating pressure of the sprays; and finally a water gage for indicating the operating pressure of the sprays.

This system has operated through a full year with a great deal of satisfaction.

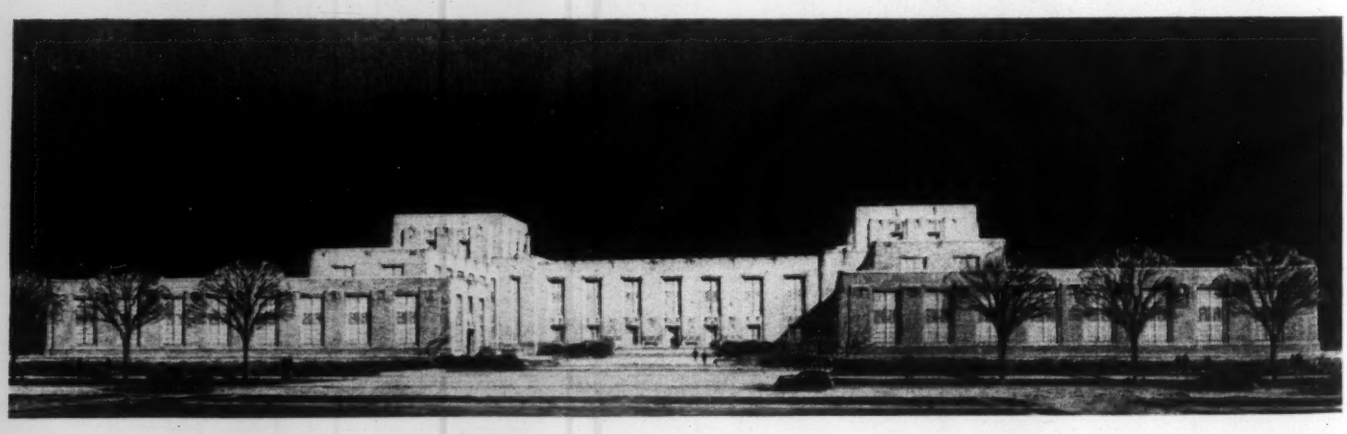
NORTHWESTERN BUILDS TECHNOLOGICAL INSTITUTE

The $5,000,000 building being erected at Evanston, Ill., to house Northwestern University's new Technological Institute is to be heated by forced hot water circulated through convector radiation, and steam in indirect heating units for lecture rooms, etc. Steam will be obtained from the university's power plant, nearly three blocks away, through a steam pipe to be laid in an existing tunnel that now carries steam power for other buildings on the campus. Pressure will be about 150 lb at the power plant and about 125 at the building.

At the point where the building intercepts the tunnel, the steam will pass through reducing valves and enter a group of seven converters, one for each of the six wings of the building and one for the central section. Water circulating through the converters will reach a temperature of 200 F. About 600 convectors will be installed. Steel pipe is to be used throughout the water circulating system and for the steam lines with wrought iron pipe for the returns, according to present plans. Copper pipe is to be used for the 40 lb steam service to laboratory tables.

Most of the underground laboratories designed for experiments and research in physics and chemistry and the ground floor of one wing of the building, devoted to the chemistry department of the university, will be air conditioned—for the most part by individual installations. Air conditioning will serve not only to eliminate undesirable fumes and to provide comfortable working conditions for students and instructors, but to control excessive humidity, which seriously interferes with delicate electrical instruments used in making precise measurements. Relative humidity tolerances will in general be kept within 5 per cent. Special air conditioning units will be installed in particular laboratories such as the moist curing room of a cement and concrete testing laboratory in the civil engineering department, in which humidity will be maintained at 100 per cent, and in the dry curing room of the same laboratory, which will have a humidity of approximately 20 per cent. Another laboratory in the chemistry department will have a temperature fixed at body heat, 98.6 F. In addition, five low temperature rooms in which temperatures may be maintained at 4 to 25 F below zero are to be constructed in various parts of the building.

Holabird & Root are the architects and engineers for the building. The consulting engineers for the power house and steam transmission to the building are Neiler, Rich & Co.



Cost of Steam With Coal as Fuel

Chart Prepared by Irving E. Brooke, Consulting Engineer, Gives Complete Data for Easily Computing the Cost of Fuel

SUMMARY

For use in his consulting work, Mr. Brooke has prepared charts for determining the cost of generating 1000 lb of steam using coal, oil or gas as the fuel. Whether the basis of comparison is 1000 lb of steam generated, a certain number of gallons of water heated, or some other basis, the relative cost will not change . . . Feature of the charts is that complete data are given, but that they are still easy to use. The one for coal is reproduced on the next page, and the others will be published later . . . To use the chart, enter it at the bottom on the scale for Btu per lb of coal and go vertically until either the per cent efficiency (diagonal lines), evaporation in lb of water per lb of coal (left hand scale), or lb of coal per boiler hp-hr (right hand scale) is intersected. From this point go horizontally either to right or left until the curve for cost of coal in dollars per ton is intersected. From this point go vertically to the scale at the top of the chart and read the cost of steam in cents per 1000 lb

MANY articles have been written on the comparative cost of various fuels, and many charts, diagrams and tables have been published tending to show the same comparative costs. It is unfortunate that many such data have been designed to show certain results—namely, that some one certain fuel was cheaper than some other fuel. The lowest price of one particular fuel would be compared with the highest price of the other fuel in a given territory, or a comparison would be given between fuels, one of which would not be at all suitable for use under the conditions assumed. It should be borne in mind that the first cost of fuel is only one of the factors involved.

All of these conflicting data leave the fuel user in a somewhat confused state of mind—a state often intensified by the over-enthusiastic salesman for any particular fuel or equipment who cites numerous instances where his fuel or fuel using equipment has replaced another fuel or equipment, and the user has saved any amount up to 50 per cent of his previous fuel cost.

Recently I prepared some charts on the comparative cost of fuels. The desire to make such charts was prompted by the fact that those available either did not cover a sufficiently wide range of fuel costs or were too much involved; that is, they gave too much information on the same chart for ready and accurate comparison, so that you were following a line until you were "lost in the woods."

After many preliminary trials, it was decided to make one chart for each fuel and to arrive at a fuel cost of 1000 lb of steam as the basis of comparison. Whether the basis of comparison is 1000 lb of steam produced, gal of water heated, or cu ft of air heated, the relative cost will not change.

My chart for coal appears on the next page; there are also charts for oil and gas which are to be published later, and a chart for quickly comparing gas costs either on the basis of the cost per therm or per 1000 cu ft of gas of various Btu values.

Use of the Chart

A feature of the chart is that it can be used if either the per cent efficiency, evaporation in lb of water per lb of coal, or lb of coal per boiler hp-hr is known. Starting at the bottom of the sheet, select the value of Btu per lb of coal and go vertically until the line intersects either the per cent efficiency (diagonal lines), evaporation in lb of water per lb of coal from and at 212 F (left hand scale), or lb of coal per boiler hp-hr (right hand scale). From this point, go horizontally either to the right or left until you intersect the curve indicating the cost of coal in dollars per ton. From this intersection, go vertically to the top of the sheet and read the cost of steam in cents per 1000 lb.

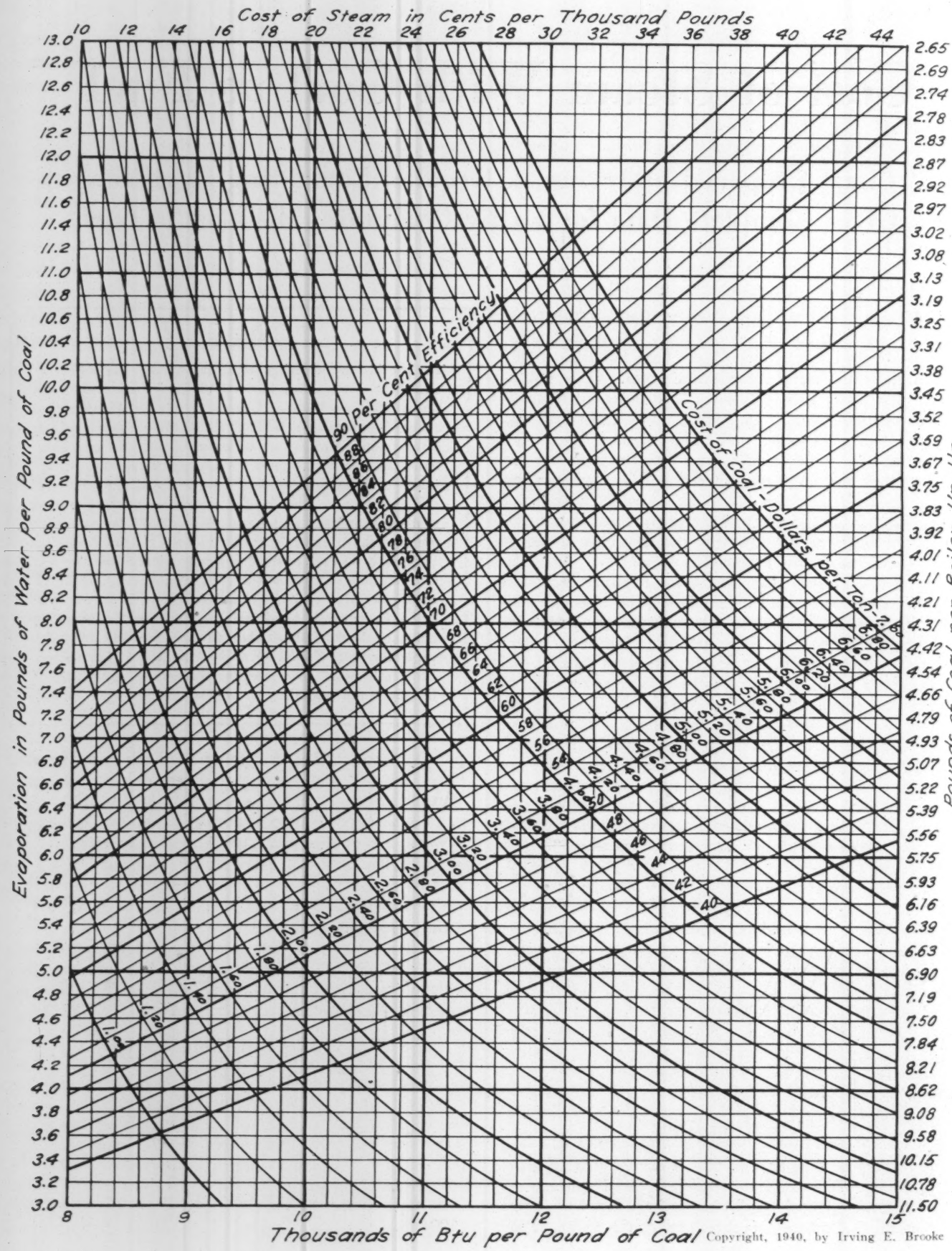
If the price of coal does not fall within the range of the chart, the method may still be used. For instance, if the cost of coal is $10, use the $5 curve and multiply the steam cost read from the chart by two.

Example of Use of Chart

Assume Btu per lb of coal to be 12,000, efficiency 56 per cent, and cost $3 per ton. Enter the chart at the bottom scale at 12,000 and go vertically to the 56 per cent diagonal line. From this intersection go horizontally to the left until the $3 curve is crossed. From this second intersection, go vertically to the top of the chart and read on the top scale the cost of steam to be 22c per 1000 lb.

Cost of Steam Using Coal as the Fuel

[See instructions for use on preceding page]



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Combination of Central Plant and Unit Air Conditioning Serves Varying Needs

F. H. Chisholm, Consulting Engineer, Tells How Different Requirements of Charity Hospital Departments Are Met

SUMMARY

The Charity Hospital of Louisiana, in New Orleans, was founded over 200 years ago, is now a $15,000,000 institution equipped to accommodate 4000 patients. Although only portions of the new 20 story main building are air conditioned, the refrigeration requirement is a little over 700 tons. . . . The air conditioning for the operating department presented some problems. The doctors made certain demands which had to be met. Recirculated air from one operating room could not be mixed with air from another. Temperature and relative humidity of each room required individual control between certain limits. Provision had to be made for removing anesthetic gases, some of which are heavier and some lighter than air. . . . The problems were solved by a combination of central plant and unit air conditioning systems

THERE towers in New Orleans today a great monument dedicated to the alleviation of suffering and the healing of the sick—the Charity Hospital of Louisiana, founded by a sailor, Jean Louis, in January, 1736. The original hospital was formerly a convent and served the dual purpose of hospital and asylum for the poor. Today, it is a $15,000,000 institution equipped to accommodate 4000 patients and some 2000 help, including nurses, internes, maintenance crews, etc. It is a small city in itself having its own ice making plant, ice cream plant, bakery, kitchen and cafeteria, cold storage rooms for meats, fruits, vegetables, etc., and a gasoline storage and filling station for trucks and ambulances.

We shall devote our attention here to the air conditioning of the new 20 story main building, and how the different requirements of the various departments are met.

Founded in 1736 by a sailor, Jean Louis, the Charity Hospital of Louisiana is now a $15,000,000 institution equipped to accommodate 4000 patients and a staff of 2000. Seven hundred tons of refrigeration is used for air conditioning parts of the building

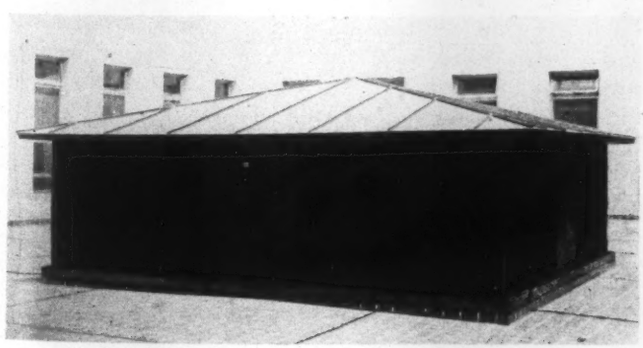
Only a small portion of the main building is air conditioned; however, it requires a little over 700 tons of refrigeration. All inside rooms — including kitchens, pantries and a number of special rooms—are ventilated. Summer-winter air conditioning is installed for the three doctors' dining rooms, the administrative suite, the accident and emergency wards, and all operating rooms and other rooms in connection with the operating department.

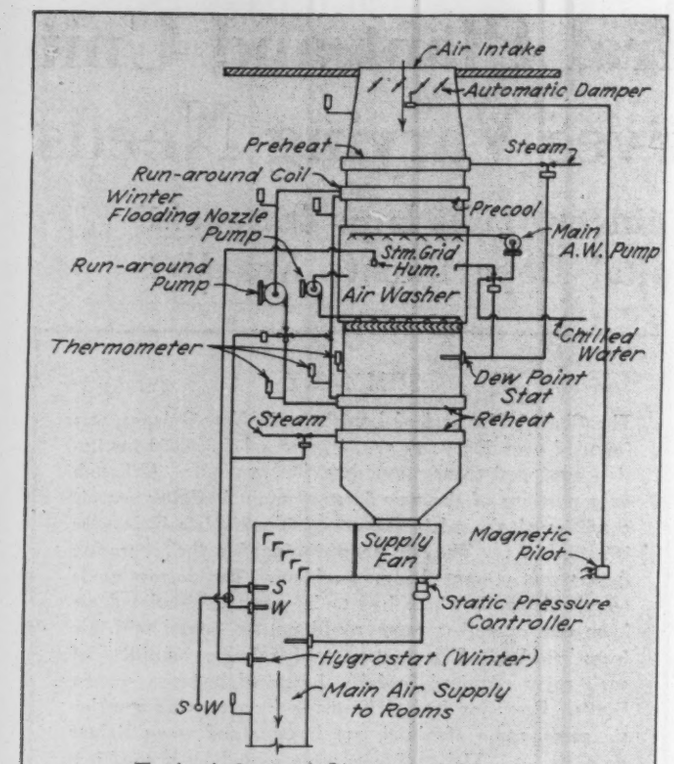
Air conditioning for all these departments (with the exception of the operating) is accomplished by the use of factory built package units. The units for the three doctors' dining rooms and administrative suite are typical factory built units, but the one for the accident and emergency wards is a large factory built unit with special control.

The operating rooms are on the 12th floor. The center portion of this floor is used for storage of instruments, linens and other supplies, and is not conditioned. The two wings house the operating rooms; in the west wing there are 19 operating rooms and in the east there are 22. In addition to the operating rooms there are numerous auxiliary rooms such as scrub-up rooms, anesthetic rooms, etc. The total number of rooms on this floor that are conditioned is approximately 100, plus the corridors. Due to the many exposures with their varying sun effects, it was decided to divide each wing into three separate and distinct zones, or three central plants.

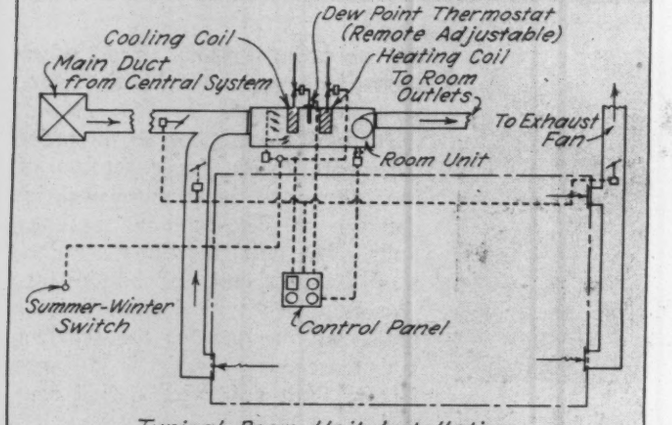
The summer-winter air conditioning for this department brought up some unusual problems. The doctors made certain demands which had to be met. Recirculated air from one operating room could not be mixed with air from another room. The temperature in each room, as well as the relative humidity, required individ-

Air intake openings are in an open court directly over the basement of each wing. Copper houses were built over the openings for the filters and heating coils. A draft gage on the exterior of each house indicates when the filters need cleaning





Typical Central Plant and Controls



Typical Room Unit Installation

ual control between certain limits, but accurately controlled. Provision also had to be made for eliminating gases used for anesthetics, some of which are heavier and others lighter than air. In order to accomplish this exhaust grilles were placed near the floor and ceiling of each operating room.

Each of the three zones mentioned was treated as an entirely separate system. One hundred per cent outside air is brought in and passed first through a preheater coil, then a run around coil, and next the dehumidifier or air washer. A second run around coil comes next and then a reheater coil. On leaving this last coil the air is picked up by a fan and then distributed to the different rooms through individual room units. These central plants condition the air in summer to about 75 F dry bulb and 60 F dewpoint.

Individual units for further conditioning the air to meet the particular requirements serve each room. Two types of units are used. For the operating and other important rooms, unit "A" consists of a heating coil and a cooling coil with bypass and a blower type fan. For auxiliary rooms the "E" units consist of only heating and cooling coils with a face damper. With the "A" units it is possible to recirculate a small amount of air, or use only outside air. The "E" units do not require close control, and only an on and off switch and a thermostat are used. The surplus air quantity is withdrawn from each room through an exhaust system, with the exhausts situated both near the floor and near the ceiling.

The "A" units are controlled from a board in each room which has an on and off switch, a thermostat for temperature control, a switch for raising or lowering relative humidity, and a recirculating air switch for regulating the quantity of air up to a maximum of 25 per cent that may be recirculated.

The control system is of the pneumatic type. Automatic dampers at the outside air intake are operated through an electro-pneumatic switch which opens the dampers when the fan operates and closes when the fan stops. There is installed in the inlet of each fan a vane control which operates by a static pressure regulator to increase or decrease the quantity of air delivered by the fans, and at the same time to maintain a constant air pressure in the ducts.

The heating system was designed for an outside temperature of 20 F; the central plant does a portion of the heating and the independent room units take care of the balance (the same idea as for summer cooling). The balance of the building is heated mainly by direct radiation and a number of special rooms have blast heating. The air washers for the summer-winter air conditioning system have steam grids for humidifying in addition to flooding nozzles. No provision was made to eliminate the possibility of the preheater coils freezing, as such danger is remote in this climate.

Autopsy Amphitheater and Morgue

Near the morgue in the basement is an amphitheater for performing autopsies which has a capacity of approximately 120 people. This room is heated by blast and is well ventilated. All supply air is taken directly from the outside and is passed through dry filters. Supply air is delivered to the room through wall grilles near the ceiling and exhaust air grilles are situated in the step risers. A separate exhaust fan is used and no air is recirculated as all contamination or annoyance from odors had to be eliminated. In order to minimize odors, supply air is treated with an ozone machine.

The morgue contains 32 compartments for bodies, plus a room called the "spare parts department" which is used for the storage of specimens for examination and study. Partition walls divide the morgue into five rooms; each has its own direct expansion unit cooler; these units are served by two "Freon" compressors each driven by a two speed motor. The compressors are controlled by pressure switches in the suction lines; the fans of the unit coolers run continuously and the direct expansion coils are controlled from the thermostats in the different rooms.

The morgue public space is heated by blast using all outside air, and has its own ventilating fan.

Ventilation of Main Building

There are a great number of rooms in the main building with no outside exposure, and a number of spaces that require ventilation even though they have windows. All such rooms and spaces are ventilated. To give some idea of the extent of this system a typical floor has about one-fifth of a mile of ducts. The total quantity of air exhaust from the building is about 425,000 cfm, using 27 exhaust fans. There are three main duct shafts, one in each wing and one in the center.

The basement exhaust amounts to about 100,000 cfm of which the kitchen alone requires almost 50,000. In order to exhaust this quantity of air, which is too large to be brought in through leakage or infiltration, it was necessary to provide for its intake. An open court directly over the basement of each wing of the building provided convenient locations, and two large intake openings were installed. Over these openings were built copper houses, and inside these houses are filters and heating coils. The coils in cool weather temper the air in order to eliminate drafts. From the intake openings this outside air is conveyed by ducts to various locations in the basement in order to obtain proper distribution.

Central Refrigeration Plant

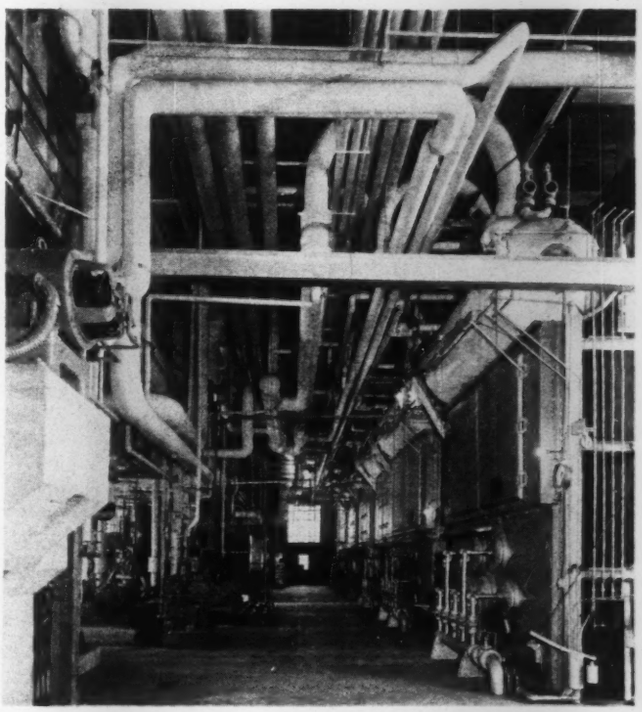
The power house for the hospital is situated about one city block distant from the main building. In the power house there are four ammonia refrigerating compressors for air conditioning. Two 175 ton single units are each directly connected to 200 hp, 300 rpm synchronous motors. Two other 175 ton units are connected in tandem with one 400 hp, 300 rpm synchronous motor, driving both compressors using a common shaft.

These four compressors are connected to a water cooler. After the water is cooled to about 47 to 55 deg. as may be required, it is pumped to the different air conditioning units in the main building.

Brass pipe was installed in a concrete trench for both the supply and return from the power house to the main building. This piping is covered with 4 in. of cork with a 20 oz copper jacket over the cork covering. The reinforced unit concrete covers were laid over the top of the trench. In the building, galvanized steel pipe is used.

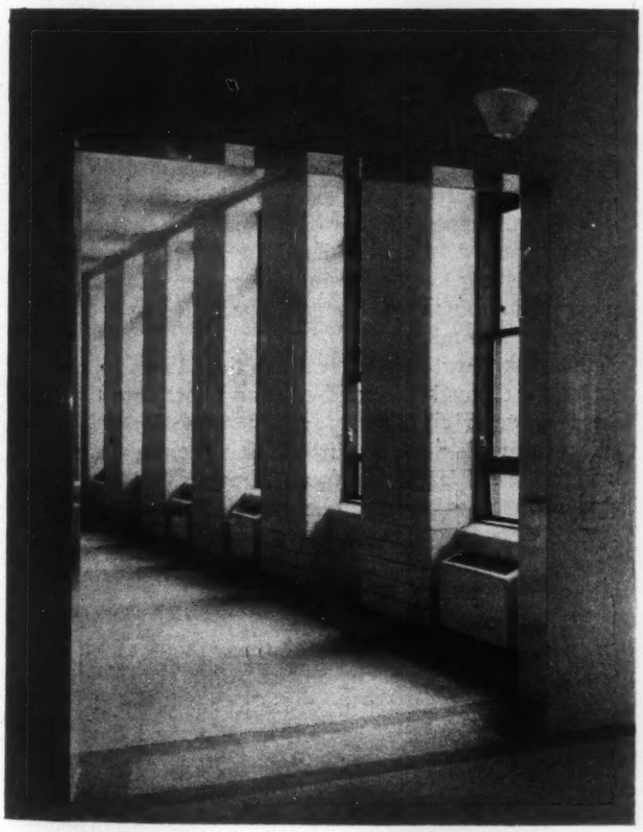
The entire mechanical equipment for the new project was designed by the writer; Weiss, Dreyfous and Seiferth were the architects; the American Heating and Plumbing Co. was the mechanical equipment contractor for the main building and laundry and ambulance house; Riggs, Distler and Co. was the mechanical equipment contractor for the power house and warehouse and shops buildings, and W. J. Riley Co. was the contractor for the nurses' home.

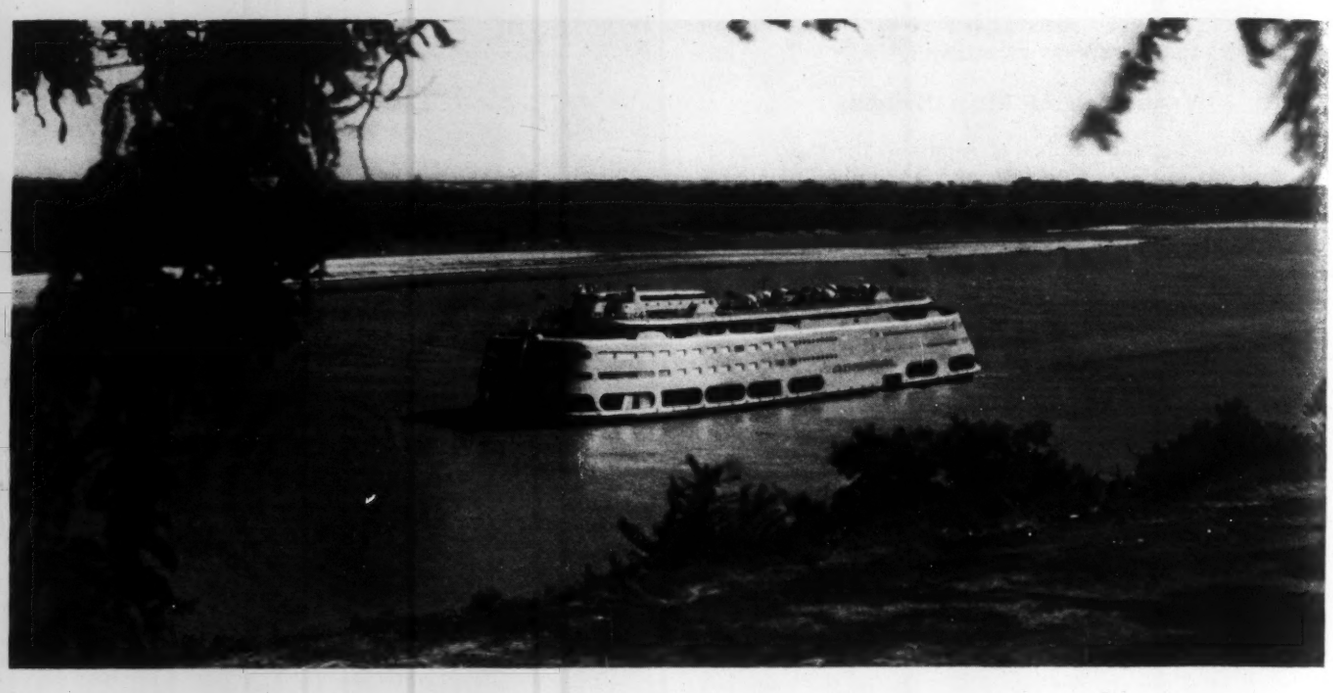
The mechanical equipment contract for the main building amounted to a little over $1,211,000, the power house and warehouse and shops buildings mechanical contract amounted to $412,000, the nurses' home mechanical contract to $161,600, and the laundry and ambulance house mechanical contract to a little over $70,000.



A view in the boiler house

Nearly 2500 sloping top convectors totaling some 90,000 sq ft of radiation, and blast heating coils with an equivalent direct radiation capacity of 70,000 sq ft, answer the heating requirements





Air Conditioned Steamboat 'Round the Bend!

By J. H. Bailey*

Mark Twain—the fellow that wrote that crack about everyone talking about the weather and no one doing anything about it that most air conditioning speeches start with—never saw anything like this in his Mississsippi River days. It's an air conditioned, streamlined excursion steamer in use at St. Louis

DANCING on the Mississippi—famed in song and story—is proving more popular than ever since the first air conditioned, streamlined excursion steamer, the S.S. *Admiral,* went into Mississippi River service at St. Louis, Mo., early this summer. The new excursion boat, one of the Streckfus steamers, is the largest and most modern inland water "liner" ever built in the U. S. It is equipped with an air conditioning system boasting a cooling capacity equal to that of the trans-Atlantic liners *Normandie* and *Queen Mary.*

A centrifugal refrigerating machine of 300 ton capacity supplies cooling for the four sets of air conditioning equipment on the boat, which serve two of the five decks —a main or dance floor deck and a mezzanine or balcony floor for dining tables. Both decks are completely enclosed.

The dance floor deck has an over-all length of 341 ft and a width of 90 ft, and there are air conditioned lounges as well as the dance floor. The dance floor is 220 ft long and 52 ft wide, with a ceiling height of 18 ft. It was built to accommodate 2500 people, 1500 of them dancing. The air conditioning system serving the dance floor and mezzanine floors is divided into four zones, each having its own separate equipment.

The equipment for each zone consists of an outside air intake, dehumidifier with six row coils, spray pump and filters. Each of the four zone systems is designed to handle approximately 18,000 to 20,000 cfm of air, which is distributed through registers in the ceiling and from the side wall under the low ceilings at the orchestra and mezzanine floor. Each of the four zones also boasts a small tempering heater for humidity correction and tempering of the outside air should the boat require a little heat in the late fall.

Condensing water is taken from the Mississippi River, discharged through the condenser and back into the river. The cold water circulating system consists of a centrifugal pump with a steam turbine drive, circulating water through the cooler to the four dehumidifier sections situated above the large paddle wheels. In installing the dehumidifiers, ingenious use was made of waste space above the wheels, reducing to a minimum the otherwise usable space needed for the air conditioning equipment on the mezzanine.

S.S. *Admiral* is constructed throughout of steel and the walls have 4 in. of wool insulation. Both floor and ceiling are also insulated in order to cut down the transmission gain from the unconditioned floor below, called the "circus" deck, and the open dining room on the third deck above. The centrifugal refrigerating machine operates on the first deck in full view of the passengers.

*District Manager, Carrier Corp., St. Louis.

"OPEN FOR DISCUSSION"

Communications to the Editor

Air Conditioning for War

THE EDITOR—

Walter L. Fleisher's editorial on air conditioning for war in the July HPAC is an excellent summary of the needs and shortcomings of many of our industrial plants. In commenting on the article I should like to emphasize the psychological effect of good working conditions on the men in the factory, which to my mind is one of the best means of defense. In fairness to the management of many plants, it should be said that much has already been done to improve working conditions. In general, however, the emphasis has been placed on those items which affect the plant production, such as the arrangement of equipment, the use of mechanical devices, lighting, etc. Less attention naturally has been given to the installation of that type of equipment which in itself does not directly increase plant production. A satisfied group of workers is, however, one of the most effective methods of obtaining increased plant production, and in addition forms a bulwark of defense in an emergency program. Whenever a management shows an interest in improving plant conditions the psychological effect on the workmen is immediate and very noticeable.

It is recognized, of course, that many plants, because of the very nature of the manufacturing process do not readily permit of complete air conditioning systems, yet a study of most plants will usually result in the conclusion that certain improvements can be made, and frequently without entailing a large outlay on equipment. I recall a certain plant where the radiation of heat from the processing equipment created an almost unbearable condition during the hot days of the summer months but maintained a normal temperature during the remainder of the year. Actual cooling was not feasible nor practical, but after some discussion the management agreed to install a fan and duct system which would bring in large quantities of outside air and distribute it to various points in the aisleways between machines. Although the actual temperature change was very small, the cooling effect was most noticeable and brought many favorable comments from the division foreman and his men. Incidentally, the net production was slightly increased due to the better manipulation of the machine and the reduction of culls.

It has been my experience for many years that general managers are not averse to improvements, provided careful studies have been made and the recommendations are based on sound judgment. Unfortunately, claims frequently made by salesmen of air conditioning equipment are such as to place the prospective purchaser in a skeptical frame of mind, with the net result that the intended improvement is often brushed aside and forgotten.

If Mr. Fleisher's editorial could be brought to the attention of managements throughout the United States it should result in a greatly increased interest in this important field.—R. S. HAWLEY, Acting Chairman, Department of Mechanical Engineering, University of Michigan. Member of HPAC's Board of Consulting and Contributing Editors.

Standby Power Questioned

THE EDITOR—

The editorial on air conditioning for war in the July HPAC raises many interesting points, but the conclusion that we should undertake a large air conditioning program for most of our factories, with complete standby diesel power plants to operate them in case the normal electric power supply is interrupted, seems open to question.

All engineers will agree that air conditioning has an important place in our industrial planning, and management officials do generally appreciate the human and economic values of providing comfort and safety for all workers. However, war is a grim business which calls for practical realism in utilizing total resources. None can safely be wasted because there is now a serious shortage of experienced design engineers, skilled mechanics, machine tools, and so forth. European nations failed for lack of war preparation, but there is no evidence that air conditioning would have saved any of them.

Air conditioning is making a sound and steady growth, but it ought not be rushed too fast under the artificial stimulus of war preparation. Cooling is a desirable feature, but not a vital necessity, for a majority of our industrial buildings. We will certainly need much air conditioning and refrigeration equipment for essential process work, and for key locations in some factories. This equipment will require a large expenditure of our engineering and manufacturing capacity for its production, and considerable power for its regular operation, but it does not seem logical to attempt a sudden expansion beyond these large necessary requirements. There are other vital military and naval needs which must have preference. The public is fully conscious of our unpreparedness, but engineers have a duty to help keep the vast rush program sane and practical.

Fortunately, we have on the whole a very favorable climate and by careful planning, reasonable comfort and safety can be provided for our industrial workers, even though complete air conditioning for comfort is obviously not now possible for the bulk of our factories. In any case, our workers will be better off than the men actually in the fighting forces, and modern war must be shared by the whole population. Air conditioning must be fully used as a tool for producing essential goods but must not be oversold as a war measure.

Engineers and architects can help the situation by insisting on heat insulation under roofs to counteract the sun effect in summer, and to reduce fuel consumption in winter. Important benefits will result from the proper use of insulation, and it should not be overlooked.

Engineers must also provide adequate natural and mechanical systems of ventilation with protection from dust, fumes, and even gas released by invaders. This gas problem is a serious one that needs careful study. Ventilating fans and blowers, fortunately, require only moderate amounts of power for their operation, and they have load characteristics favorable for auxiliary drive by small standby prime mover plants. In some hazardous locations, such standby plants may be necessary to take care of emergency ventilation in case the main power supply should be temporarily interrupted.

Manufacturing work cannot be carried on normally without power, and it seems unnecessary to provide standby equipment for the temporary operation of cooling apparatus. Aside from the strictly engineering viewpoint, it would also be unwise to divert large resources for a program of building individual standby plants, merely to run cooling systems for comfort during periods when the manufacturing must stop anyway because of interrupted power supply. These resources

can be applied to better use for our national defense.

Of course, cost considerations must not delay our defense measures, but waste must be avoided and unnecessary standby plants would represent waste in first cost and in technical resources. They would also create a heavy burden of idle maintenance and obsolescence. War will not be permanent, and in peacetime such equipment is utterly useless.

Mr. Fleisher stresses the danger due to interruption of our main power supply systems, and this is certainly one of our major problems, because our whole industrial system is keyed to power. Remarkable progress has been made in arranging power distribution so as to localize outages and maintain service under all conditions. Further protection of key points will be needed under war conditions, but our principal concern must be for this maintenance of our main power supply. Most of our activities depend upon power, and even for an individual factory it is more important to run the machines than to provide cooling while work is shut down for want of power.—Lee P. Hynes, Electrical and Mechanical Engineer. Member of HPAC's Board of Consulting and Contributing Editors.

Conditioning Reduces Absenteeism

The Editor—

I read Mr. Fleisher's editorial on air conditioning for war with a great deal of interest. I believe his general idea is sound, but the expense involved is perhaps prohibitive. This is particularly so where this new high pressure work will be done in new plants and the entire plant expense must be amortized in five years. The manufacturer will provide air conditioning for his engineering and clerical help because this is apparently necessary, but generally he will not do it for the rank and file of factory employees.

I believe that the air conditioning industry has been very lax in not making the data more generally available on air conditioning's advantages. I believe that there are many statistics available which can be satisfactorily published and which would help the cause considerably.

In one important job of mine they had definite employee absence records extending over quite a period of years. When they moved into their new plant, which was completely air conditioned, they continued to keep these records, and these records show that over a period of four years the absences on account of sickness had been reduced 38 per cent. They give the air conditioning system the full credit for this improvement. In this plant they found that the improvement took place fairly uniformly throughout the entire year, regardless of weather conditions. This indicated to them the desirability of their operating the equipment continuously, which has been done.

It has been my thought that if manufacturers could be convinced that there was a definite money saving to be effected by improved health conditions of employees, due to working in air conditioned space, they would give the matter much more serious consideration.

Frankly, I believe that we are wasting our time worrying about these more or less temporary enterprises which are coming in with the war scare and will go out within a few years. I am thoroughly convinced that industry in general needs air conditioning and should be made more conscious of this fact. Not enough publicity has been given to the necessity for and benefits of air conditioning.—Elliott Lee Ellingwood, Consulting Engineer. Member of HPAC's Board of Consulting and Contributing Editors.

Designing a Duct

The Editor—

In the April HPAC, p. 252, Samuel R. Lewis endeavored to answer a reader's question about the correct method of designing a duct. You quote the reader's problem as follows: "Consider that a fan is delivering a quantity of air to a horizontal rectangular wooden duct of 100 ft length. It is desired that this air be blown out of equal sized uniformly spaced nozzles along the entire base of the duct. The velocity out of each nozzle should be constant and equal to 1000 fpm. How should the duct be designed?"

As I interpret this question, it is for the specific problem mentioned and does not ask for a general method of duct design. Mr. Lewis' answer gives a general description of the accepted methods of duct design only and does not answer the specific question asked. If the duct were designed by one or the other of the methods indicated, it would not work properly. The actual condition that would result would be that the outlets near the beginning of the duct would get very much more air than the outlets near the end.

The problem specifies equal area, equal quantity and equal velocity out of each outlet. In order to obtain this condition, exactly equal static pressures must be maintained behind each outlet. We know that the pressure at any point in the duct is: Total Pressure = Static Pressure + Velocity Pressure; therefore, theoretically, we would have to have a condition whereby the total pressure would be equal to the static pressure; this static pressure being the same behind each outlet. This can be achieved only by having a duct of infinite dimensions so that the velocity in the duct (and therefore the velocity pressure) and the frictional resistance would be equal to zero. The magnitude of this static pressure would be exactly equal to one velocity head of the air through the nozzle plus the resistance to the air offered by the nozzle. A duct of infinite dimensions, however, does not solve the reader's problem. I think it is evident, though, that it is impossible to get the exact conditions he specifies, from a practical standpoint.

In order to solve this problem, practically, I suggest any one of the following methods:

1) Make the duct as large as possible and keep the same size duct for the entire length. This will reduce the frictional resistance and the velocity pressure considerably. There will still be a variation, however, between the first and last outlet. The amount of this difference will get smaller and smaller as the duct gets larger.

2) Design the duct as indicated by Mr. Lewis but vary the velocity of the nozzles. In other words, the first outlet will have a high velocity and the last a low velocity. The objection to this method is that it affects the air distribution in the conditioned space because the length of blow will vary.

3) Design the duct as in (1) or (2) and use some device for controlling the amount of air out of each outlet. This can be done with devices available on the market.—Gordon Midboe.

The Editor—

I appreciate Mr. Midboe's comments on my attempt, made in good faith, to answer the question as to how to design a duct 100 ft long so as to make equal sized, uniformly spaced nozzles each deliver the same volume of air. Evidently I bumbled, not realizing that the asker was so smart and that this was a trick question.

Mr. Midboe's answer No. 3 would give the most reasonable design. Another solution would be to run a separate duct all the way from the fan outlet to each nozzle, these ducts each being of different and proper size to insure equal velocities of air in each after expanding behind the equal sized nozzles—Samuel R. Lewis, Consulting Mechanical Engineer. Member of HPAC's Board of Consulting and Contributing Editors.

Readers of Heating, Piping and Air Conditioning are invited to contribute their views to these "Open for Discussion" pages, which will appear from time to time. Comments on articles we have published, expressions of timely interest on developments in design, installation, operation or maintenance of heating, piping or air conditioning systems, other remarks of value to HPAC's readers—all will be welcome.—The Editor.

How Much Steam for Heating?

New Study of Heating Economies — Highlighted Here — Shows Steam Consumption for Various Types of Buildings

IN its work during the past two years, the joint committee on heating economies of the National Association of Building Owners and Managers and the National District Heating Association has had the following objects in view: (1) To determine a standard quantity of steam necessary properly to heat buildings of various sizes and occupancies; (2) to determine the economies produced by the use of control apparatus; (3) to make a study of the comparative efficiencies of different types of heating systems and kinds of control apparatus; and (4) to determine which kind of control apparatus functions best on the several types of heating systems.

The committee felt that last year's report (see HPAC, October and November, 1939) was based upon an insufficient number of buildings to justify wholly dependable conclusions and recommended that the work be repeated this year with a much larger quantity of data. Evidently last year's report aroused the interest of members, because this year returns were received from over 1000 buildings. Only a few of the "highlights" of the report are given here.

The study was based on buildings using purchased steam and on buildings producing steam. The results given here are from the former group.

Each of the slanting lines on Fig. 1 represents the steam consumption of an office building at various volumes for a fixed number of hours of occupancy. It is therefore possible to determine from this chart the steam per degree day which an office building should consume to be in line with all the other buildings in this group if its volume and number of hours of occupancy are known. Then the difference between this theoretical figure and its actual steam consumption will represent the diversity due to type of heating system, kind of control and personnel efficiency after the influences of hours of occupancy and volume have been eliminated.

Type of Heating System

Some types of heating systems are more efficient than others. For instance, the office buildings having the one pipe gravity system used 52,602 lb of steam per degree day as against a calculated mean amount of 43,704 lb, or a diversity of 8898 lb. The actual steam of this system was therefore 120 per cent of the mean requirements. On the other hand, the orifice vacuum systems had an actual steam consumption of 138,183 lb of steam as against a mean requirement of 148,781 lb, which represented a saving of 10,598 lb; their "diversity factor" was therefore 93 per cent. It should be pointed out that only groups having a sufficient number of buildings should be considered as giving reliable results. Groups having less than 20 buildings will give results that may be unreliable. Eliminating these groups, the remaining heating systems have the following comparative efficiencies:

Type of Heating System	*Diversity Factor, Per Cent*
One pipe gravity	120
Two pipe gravity	108
Two pipe vacuum	98
Orifice gravity	97
Orifice vacuum	93

Effect of Control

In like manner, the buildings were then regrouped according to the kind of control apparatus. The diversity factors for the several kinds of control apparatus were found to be as follows:

Type of Control	*Diversity Factor, Per Cent*
Inside key thermostat	113
Hand control	111
Manual cycle	105
Automatic cycle	98
Variable cycle	97
Pressure differential	93
High vacuum	76

In order to still further analyze the effect of type of heating system and kind of control, the buildings for each type of heating system may be sub-classified according to kind of control. The effect of an efficient control device is greatest on an efficient heating system. For instance, hand control on a one pipe gravity system has a diversity factor of 129 per cent, whereas on an orifice vacuum system it has a diversity of 112 per cent. Also the variable cycle on a one pipe gravity system has a diversity factor of 106 per cent, whereas on an orifice vacuum system it has a diversity of 83 per cent.

SUMMARY

The current report of the joint committee on heating economies of the National Association of Building Owners and Managers and the National District Heating Association contains a wealth of data on steam consumption for heating. It was prepared by Earle Shultz and J. C. Butler, vice-president and chief operating and commercial engineer, respectively, of the Illinois Maintenance Co. Although primarily devoted to office buildings, information is given on a number of other occupancies, such as apartments, hotels, department stores, warehouses, theaters, banks, loft buildings, etc. . . . . Only a few of the highlights of this voluminous study are presented here; the object has been to brief some of the findings for easy reading and yet to give some of the more important conclusions of this complete analysis

Effect of Type of Occupancy

In Fig. 2, the distance of the lines above the base of the chart indicates the relative amount of steam required for each type of building. For instance, the line for garages, being very much closer to the base than the one for apartment houses, indicates the obvious fact that garages require a smaller amount of steam per degree day for heating than do apartment houses.

Because most types of occupancy except office buildings have rather uniform hours of occupancy, separate curves were not drawn for different hours of occupancy. The lines on Fig. 2 (including that for office buildings) are based upon the average hours for each group. If the hours of occupancy of any building differ greatly from the average hours shown on its line on Fig. 2, the mean steam requirements may be calculated from formulas given in the committee report. The formula for office buildings using purchased steam is shown on Fig. 1.

A comparison of data in the committee report showing the influence of type of heating system on steam consumption for occupancy classes other than office buildings shows that the one pipe gravity system—which was least efficient in the office building group—is a trifle better than the average in this group. On the other hand, the orifice gravity and orifice vacuum systems are not as efficient as in office buildings. In the office building group a much larger percentage of the buildings have orifice gravity and orifice vacuum systems than in the other groups. Also in the other groups of buildings there are about twice as many two pipe gravity jobs, and the efficiency of this group is a little better than in the office buildings.

As to the influence of kind of control on steam con-

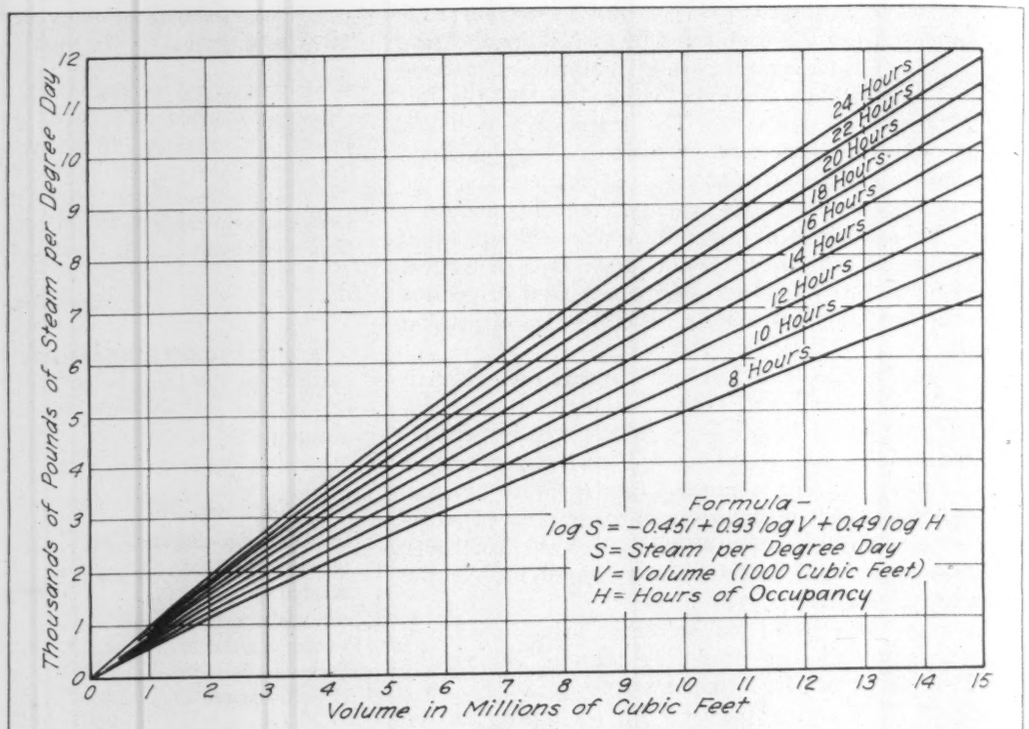


Fig. 1

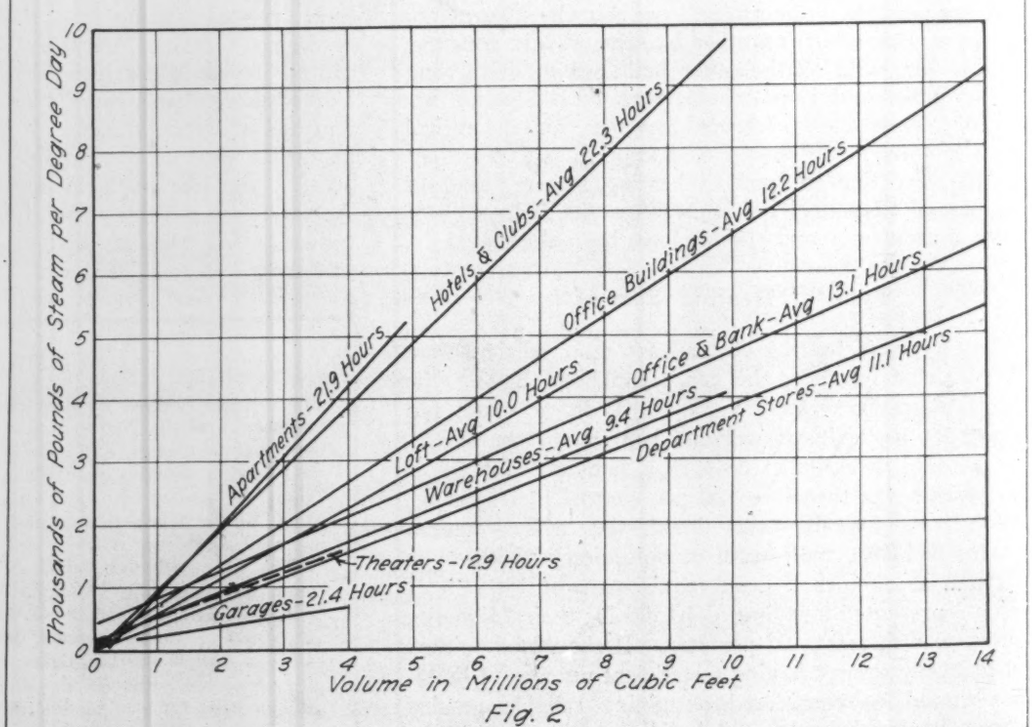

Thousands of Pounds of Steam per Degree Day
Volume in Millions of Cubic Feet
Hotels & Clubs-Avg 22.3 Hours
Office Buildings-Avg 12.2 Hours
Office & Bank-Avg 13.1 Hours
Department Stores-Avg 11.1 Hours
Warehouses-Avg 9.4 Hours
Loft-Avg 10.0 Hours
Apartments-21.9 Hours
Theaters-12.9 Hours
Garages-21.4 Hours

Fig. 2

Fig 1 (above) — Office building heating steam requirements per degree day depending upon the building volume and the hours of occupancy. . . . Fig. 2 (below) — Comparison of heating steam consumption on degree day and building volume basis for different types of occupancy. Average hours of occupancy for each type of building are indicated on the chart

sumption for occupancy classes other than office buildings, it was indicated by the committee report that inside key thermostats, hand controls, individual radiator thermostats and variable controls are more efficient than in the office buildings; while the automatic cycle, pressure differential and high vacuum are not as efficient. More of the other buildings use inside key thermostat and hand control systems than do the office buildings. It is probable that the orifice types of heating systems and the more complicated control devices function better in office buildings, where they are adequately maintained by efficient organizations, than in other types of buildings where they may be operated by less efficient personnel and might not be maintained in good condition.

The complete report of this study of heating economies is to be published in the 1940 Proceedings of the National District Heating Association, 1231 Grant Bldg., Pittsburgh, Pa.

Air Conditioning Guards Knife Blades from Rust

Rust—summer plague of manufacturers maintaining stocks of expensive metal parts—has been eliminated as a loss factor by the Imperial Knife Co., Providence, R. I., through an air conditioning installation in the stock room. Because several million pocket knives are kept in stock, the company suffered substantial losses each summer when moisture condensed out of the air and rusted the highly polished knife blades. Last year executives of the firm ordered two 3 hp unit air conditioners. After a full year's operation, they report that the rust problem has been completely eliminated, and incidentally summer comfort provided for stock room employees.

A unique feature of the installation is the occasional use of a heating coil, in summer. This reheat coil operates to prevent over-cooling when the refrigerating machine has a heavy dehumidification load but a light cooling load, as on cool, clammy days.—J. T. SCHAEFER, General Electric Co.

AIR CONDITIONED SUPER-MARKET

Carls air conditioned market on Tamiami Trail is the third and largest of a series around Miami, Fla., built by Aaron Weinkle during the past year and a half. The store is 130 by 185 ft, has 24,050 sq ft of unbroken floor area (no columns), ½ mile of shelving and display counters and 16,650 sq ft of actual merchandising space—every bit of which is air conditioned.

Air conditioning serves several important purposes in a food market of this kind: (1) It provides a "haven of refuge" from the summer heat for customers, attracting more trade, encouraging customers to linger longer and buy more. (2) It increases the efficiency of the employees, puts "pep" into the organization when they need it most. (3) The clean, cool air retards spoilage of perishable foods which are on open display and helps eliminate food odors. (4) It also cuts down infiltration of dust and dirt into the store—year-'round.—J. L. ROSENMILLER, Manager, Sales Promotion Div., York Ice Machinery Corp.

Here's Where Air Conditioning Is Used

Following is a summary of the total air conditioning installations by business classifications as reported by 183 operating utility companies to the air conditioning committee of the Edison Electric Institute. These companies serve a population of approximately 75,000,000 people. The EEI report from which the data are reproduced was reviewed on p. 476 of the August HPAC.

Variations in the average horsepower of air conditioning systems for various types of service is conspicuous throughout the report. The average doctor's or dentist's office, for example, uses only 2 hp. The average public building installation requires 142 hp.

Many industrial plants find air conditioning an important contribution to successful operation. In the food processing industries, particularly, great strides have been made in this direction since the publication of the institute's 1939 report, and this group now ranks first in the number of industrial installations.

	Total as of 12/31/39 No.	Hp *
Residential		
Apartments Private Homes	9664	17348.90
Commercial		
Apartments	82	2466.65
Banks	526	19777.80
Barber & Beauty Shops	645	4205.98
Broadcasting Studios	156	4825.80
Clubs	268	5039.07
Funeral Homes	683	6353.73
Hospitals	420	6684.18
Hotels	1087	45644.31
Office Buildings	974	96054.02
Offices, Doctors & Dentists	1360	3193.26
Offices, Miscellaneous	8308	55536.72
Public Buildings	363	51603.10
Recreational	142	3007.76
Restaurants	4518	73255.17
Stores, Department	806	87899.64
Stores, Drug	785	9406.96
Stores, Retail Misc.	4889	76658.57
Theaters	1942	167280.92
Other Commercial	1861	29373.19
Industrial		
Candy Mfg.	181	10009.92
Drug & Chemical Mfg.	60	2949.80
Printing & Lithographing	112	6848.96
Textile Mfg.	43	2287.00
Tobacco Mfg.	27	1500.43
Metal Working	9	325.00
Food Processing	268	6035.54
Fur Storage	120	637.61
Other Industrial	2190	74472.94
Miscellaneous Industrial Unclassified	**115	2341.15
Total Installations	42604	873024.08
Installations included above that use power other than central station electric	263	8799.21
Self-contained conditioners included above:		
1½ hp or less (room coolers)	10786	7645.13
2 hp or larger (store units)	2689	13297.59

*Hp includes all auxiliaries.
**Totals only—no segregation statistics submitted.

The Use of the Ring Joint on Oil and Steam Piping Service

Tests on Ring Joints for High Temperatures and Summary of Conclusions Presented by F. R. Venton* and A. W. Marburg†

BECAUSE it was realized that fluctuating line temperature conditions were the greatest single cause for flanged joint leakage, an investigation of the characteristics of the ring joint was undertaken with special emphasis placed upon the ability of the ring joint to withstand temperature fluctuations. The first and second series of the quench tests were described last month, as was the use of water for quenching.

Hub Contraction of Welding Neck Flanges

The results of the water quenches lead to a consideration of temperature changes taking place in the hub or neck of the flanges during a quench. A thermocouple placed on the cap immediately adjacent to the weld (Joint *C'*, shown on p. 492 of the August HPAC) provided temperature readings which showed clearly what was taking place. The results are graphically portrayed in Figs. 1 and 2. The temperature of the neck of the flange decreased so rapidly during a water quench as to actually cause a temporary increase in bolt load. Isolating a section of the flange, and considering the action of the hub contraction on this section, will perhaps show more clearly what takes place; this has been done in Fig. 3. In spite of the rapid cooling of the flanges

*Technical Engineer, Research and Development Dept., Crane Co.
†Testing Engineer, Research and Development Dept., Crane Co.

SUMMARY

An investigation of the characteristics of the ring joint, with special emphasis on its ability to withstand temperature fluctuations, has been reported in three articles, of which this is the last. The conclusions which may be drawn from the test work and discussion are as follows: (1) Joints assembled with rings of octagonal cross-section exhibited better pressure retaining abilities under conditions of fluctuating temperatures than did the joint assembled with a ring of oval cross-section, or any of the joints of the large tongue and groove design. . . . . (2) Substantial temperature differentials exist between the component parts of any flanged joint when the temperature of the fluid being transmitted is changed. The thin sections of metal close to the axis of the joint change temperature more rapidly than the heavier flange section, causing flange rotation which may cause leakage. It cannot be concluded that the more severe the temperature differential between the joint and the fluid the more severe the joint leakage will be. The stress irregularities caused by temperature differentials in a flanged joint will be conducive to excessive bolt load losses if the condition is recurrent. . . . . (3) Blind flanges should never be used where a condition of sudden temperature reduction of the fluid in the line can be anticipated, as the temperature differentials so introduced cause a drastic reduction in gasket and bolt loads resulting in leakage. In some cases it may not be objectionable to have leakage for very short periods (namely, while the temperature differentials exist) but such a procedure is extremely hazardous as the cumulative erosion or cutting of the seating surfaces, either on the gasket or flanges, will necessitate a shut down for joint repair, a most costly procedure. It is suggested that wherever it is necessary to close off the end of a line, that unless there is absolute certainty of temperature constancy, a domed flange with a thin hub section be substituted for the conventional flat blind flange. This is for the purpose of compensating for slight temperature irregularities. . . . . (4) The bolt load losses were excessive on the tests here discussed. During the second series of tests where the flanges, bolts and cross were being used for the second time the percentage bolt load loss was approximately the same as for the first series. As the second assembly was subjected to three times as many quenches as the first assembly, and as the average initial bolt load of the second series was higher than the first series, it is significant that the loss of bolt load was the same in both cases. Creep tests and other flanged joint tests have indicated that the curve of load loss has substantially changed its slope after 200 hr of operation, and it is on this basis that a retightening of flanged joint bolting after 200 hr has been recommended. . . . . (5) Pressure determinations made in the groove of a ring joint indicated that the outside bearing of the ring broke its seal whenever the joint was subjected to a quench, but that the inside bearing was tight, with the result that no steam leakage took place. The sealing of the inside bearing surface of the ring was due to two causes: (A) The ring contracted faster than the groove, as the groove was an integral part of a large hoop which was much hotter than the ring; namely, the outside of the flange. (B) The rotation of the flange due to the hub contraction tended also to break the outside sealing surface and increase the load on the inside bearing. . . . . (6) From the discussion it is apparent that the flanges which form a part of a ring joint assembly may be separated farther than the flanges forming a flat gasket assembly, all other factors being equal, before leakage commences, as a unit flange separation in the case of the ring joint produces only fractional bearing surface separation. . . . . (7) If a ring and small tongue and groove joint of the same size are both assembled with the same total bolt load, the ring joint may have greater bearing area and greater unit load on that bearing area than the flat gasket in spite of the fact that the total load is the same in both cases. This is, of course, due to the wedging action of the ring. Although experimental work is continuing with the idea of perfecting a more effective pressure seal, the ring joint using a ring of octagonal cross-section has proved to be superior to any of the other joints tested, and, in the authors' opinion, is the best flanged joint available today for high temperature service

with respect to the bolts during a quench—a phenomenon which tends to decrease the bolt load—it is possible to achieve an increase in bolt load as a result of the more rapid hub contraction.

Blind Flanges

The rapid hub contraction theory led to a further consideration of difficulties which might be experienced with blind flanges when subjected to quenching conditions. In the case of a blind flange on the end of a header which is normally maintained at some uniform high temperature but which is occasionally subjected to the internal quenching effect of some much cooler fluid, it is apparent that a substantial temperature gradient will exist between the inner and outer surfaces of the flange. As the outside of the flange will be hotter than the inside, the attempted contraction of the inside surface will cause a bowing of the flange convex outward as shown in Fig. 4. As the ring load is applied closer to the center of the flange than the bolt load, the flange rotation or bowing will cause a reduced bolt load and gasket load resulting in leakage during such a quench.

In order to substantiate the theory a 6 in. 300 lb joint was assembled consisting of a blind flange, a welding neck flange and a ring of octagonal cross section. The blind flange was drilled and tapped for a ¾ in. connection. The welding neck flange had a cap welded to it with a ¾ in. outlet in the center of the dome.

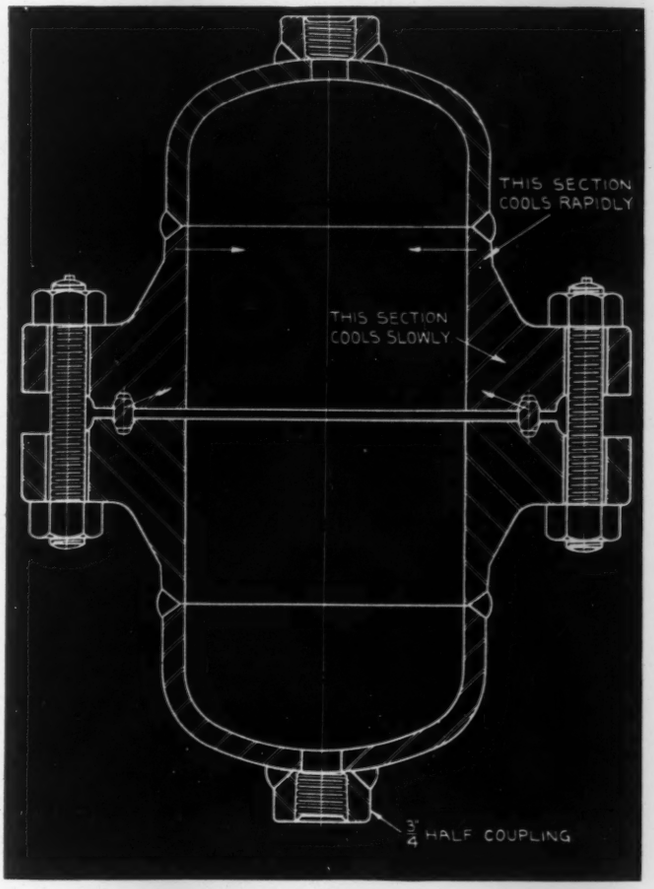


Fig. 3 — Forces acting on flange when joint is subjected to quenching conditions

The assembly was mounted in precisely the same manner as the joint shown in Fig. 5. The inlet was at the bottom of the assembly through the dome of the cap on the welding neck flange, and the outlet was on the top through the blind flange. It must be remembered that with this test set up, the bowing of the blind flange was in part counteracted by the hub contraction of the welding neck flange.

Mounted adjacent to the blind flange assembly was a pair of welding neck flanges made up with a ring of octagonal cross section. The two assemblies were connected in parallel, so each test joint received precisely the same treatment. The temperatures, pressures and procedure were substantially the same as those of all previous tests. The initial bolt stress on both joints was 20,000 lb per sq in. On the first two quenches (both steam), severe leakage of the joint made up with the blind flange was experienced; the joint made up with the two welding neck flanges exhibited slight leakage. On the third quench—a water quench—the joint with the two welding necks was tight and the blind flange joint leaked severely. The bolt stresses were then increased to 40,000 lb per sq in. On the next quench, which was steam, severe leakage of the blind flange assembly was still experienced; the welding neck assembly was tight.

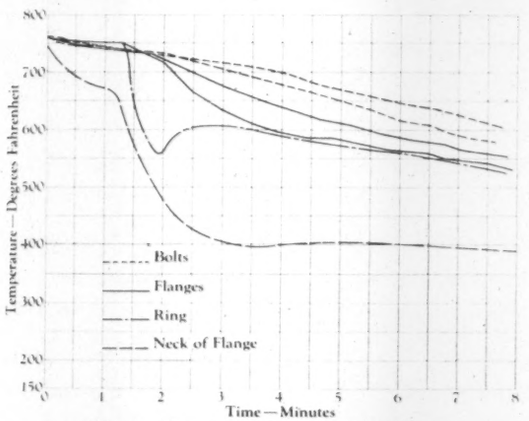
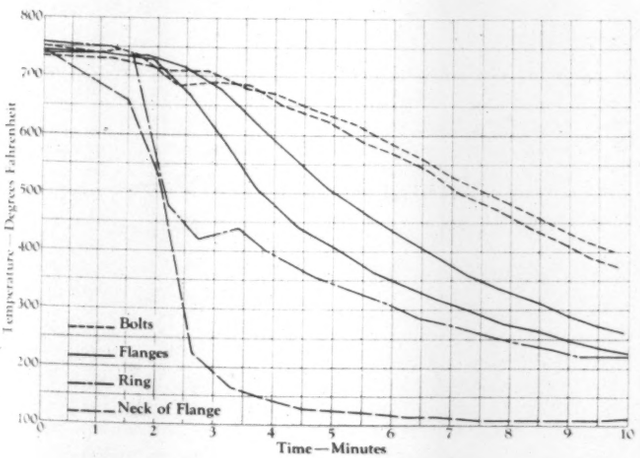


Fig. 1—Octagonal ring joint, steam quench, second series. 50,000 lb per sq in. initial bolt stress

Fig. 2—Octagonal ring joint, water quench, second series. 50,000 lb per sq in. initial bolt stress



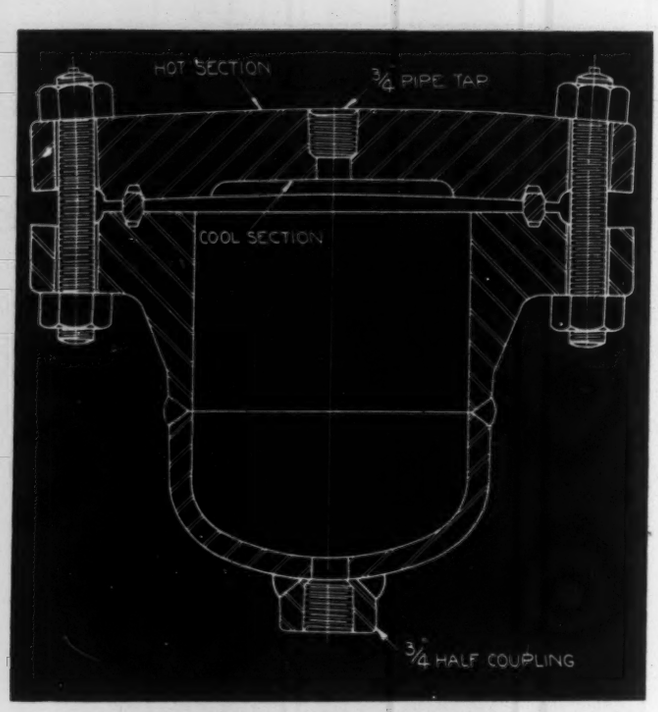
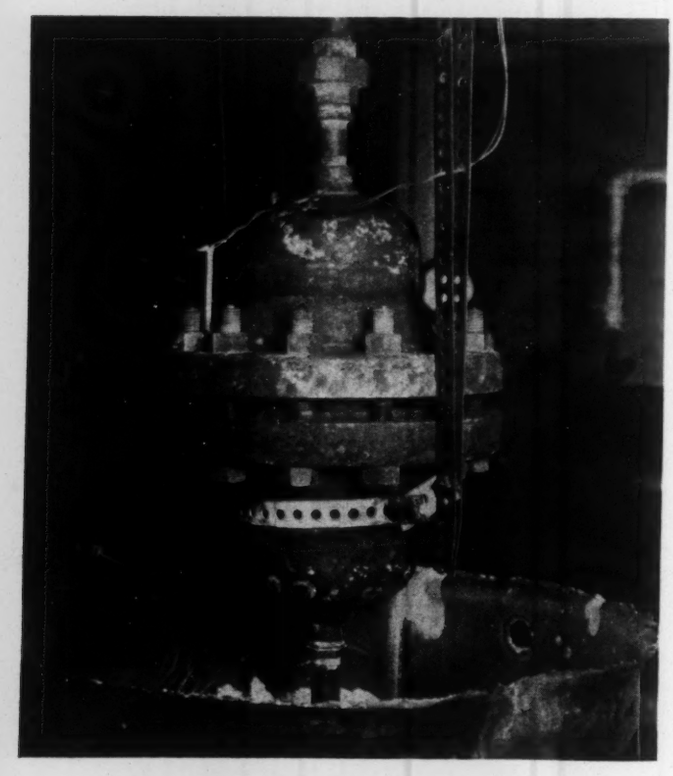


Fig. 4 — Blind flange subjected to quenching conditions

As a further substantiation of the theory, a 14 in. blind flange, assembled with ring of octagonal cross section, on the end of the main header of a power plant operating at 1275 lb per sq in. and 910 F, which had been causing the operators difficulty when subjected to quenching conditions, was replaced over eight months ago by a domed flange which has been performing satisfactorily.

Fig. 5—Test assembly of individual joint



Bolt Load Loss

In a plant operating at 1475 lb per sq in. and 900 F, where some bonnet joint leakage had occurred, a survey of the installation was made. It was found that the boilers were shut down every other week. The temperature differentials existing between the component parts of one of the 6 in., 1500 lb gate valves installed in this plant are shown in Fig. 6.

This valve was being warmed up with a small drain line as the only opening for steam circulation. The center of the body warmed up faster than the bonnet flange, causing a maximum temperature differential of 240 F. The maximum differential between the center of the bonnet and the bonnet flange amounted to 160 F.

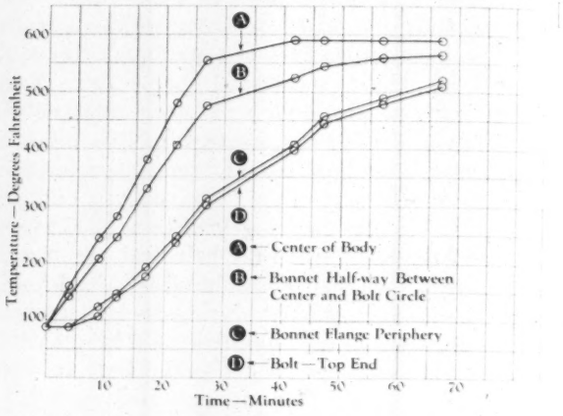


Fig. 6—Temperature differentials during warming up of insulated 6 in., 1500 lb gate valve

These differentials caused a flange rotation about the ring. It can further be anticipated that the process of cooling the valve, when the cooling is achieved by reducing the temperature of the fluid circulating through the line, results in temperature differentials similar in magnitude, only reverse in direction. The severe variations in flange, bolt and ring stresses were in part responsible for high bolt load losses. The bolt studs were retightened a few months ago. No further difficulties have been reported. The bolt load on any conventional flanged joint marketed today must be maintained to assure tightness. In order to maintain the bolt load of a flanged joint on high temperature service, it is recommended that the bolts be retightened after the first 200 hr of operation and again after six to 12 months, depending upon the severity of the operating conditions.

[This is the third of three articles on the ring joint for oil and steam piping service. The others appeared in the July and August issues of HPAC.]

Marking System for Valves, Fittings, Flanges and Unions

The Manufacturers Standardization Society of the Valve and Fittings Industry, 420 Lexington Ave., New York, N. Y., has adopted an Addendum No. 2 to its standard marking system for valves, fittings, flanges and unions, SP-25-1936. It includes and supersedes Addendum No. 1 and is intended for the purpose of clarifying rule 2b and including in rule 4b the products made of alloy steels recently added to American Standard B16e.

Absorption Refrigeration Used for Air Conditioning

W. F. Friend* Outlines Progress in Applying This Type of Equipment in Air Conditioning

AN incentive to the district steam industry to devise means by which it may become possible to secure the highly desirable summer air conditioning load is the huge summer valley in annual send-out curves. Combination electric and steam utilities confronted with the rapid shift of their annual electrical peak from winter to summer months have even more at stake. Moreover, areas served by district steam companies are those in which the highest concentration of commercial comfort air conditioning is found.

There are several methods for accomplishing with steam the summer functions of dehumidifying and cooling. Entering this field, absorption refrigeration presents an alternative operating principle and a different type of equipment. It does not offer anything basically new with respect to the air treating process itself, since the refrigeration effect for cooling and dehumidifying is applied in conventional manner by means of finned coils or air washers. The parts required for a simple absorption unit are a cooling coil, in which liquid refrigerant evaporates; an absorber, in which refrigerant vapor is dissolved in solvent liquid; a solution pump to transport the refrigerant-solvent solution from the low pressure to the high pressure zone; a generator (more frequently called the "heater") in which refrigerant vapor is driven out of the solution; the condenser in which refrigerant vapor is restored to liquid form; and a heat exchanger which acts to transfer heat from hot solvent to cool solution. As refrigerant and solvent, ammonia and water have generally been used in the past, but other substances and chemical compounds of suitable characteristics are available.

The services required for operation comprise heat in some form, for the generator, to drive refrigerant vapor out of solution; cooling water to remove heat liberated in the absorber and in the condenser, and power for the solution pump, unless thermo-siphon effect is utilized.

Experiments for production of cold by means of energy in the form of heat antedate use of compression for refrigeration, partly because the absorption apparatus was easier to build in the laboratory from the materials at hand. There was an era in refrigeration practice when absorption apparatus came close to dominating the heavy refrigeration field in ice plants and cold storage warehouses. Decline of ammonia-water absorption took place before the advent of air conditioning and the principal factor contributing in both of these events was the same —namely the development of compact, efficient, low cost, reciprocating compressors well adapted for motor drive.

In spite of recognized deficiencies in the old absorption apparatus, the method never became totally eclipsed and in Europe particularly technical interest has been maintained and research carried on. Recent attention has been focused mainly, however, on applications for extremely low temperatures demanded for industrial processes rather than on the range of temperature above ice freezing which is used for comfort air conditioning. The absorption refrigeration cycle has found its most common application in the household refrigerator introduced in the U. S. A. more than a decade ago.

A little over two years ago certain natural gas utility companies undertook to ascertain what measures might be necessary to enable them to expand gas sales for air conditioning—especially in the residential field. One outcome was the conclusion that absorption refrigeration in some form or another offered important possibilities. Coöperative efforts were arranged with three manufacturers in particular, which on their own initiative already had begun work along these lines.

Aggregate capacity reported by one of these manufacturers, as built since the first unit was finished for exhibit at the Chicago world's fair in 1934, is 1200 tons, of which 900 tons in 67 units had been sold before the end of 1939 and the remainder constitutes 1939 models in stock now being sold. One installation comprising six units is operated on district steam at Kansas City, Mo.; the others use steam generated on the premises with gas or oil fuel.

One of the other manufacturers built and placed in service outside the factory during 1939 three units each rated at 5 tons cooling capacity, one of which was in the gas industries model home exhibit at the New York world's fair. A 3 ton model is planned to supplement the 5 ton size now in production.

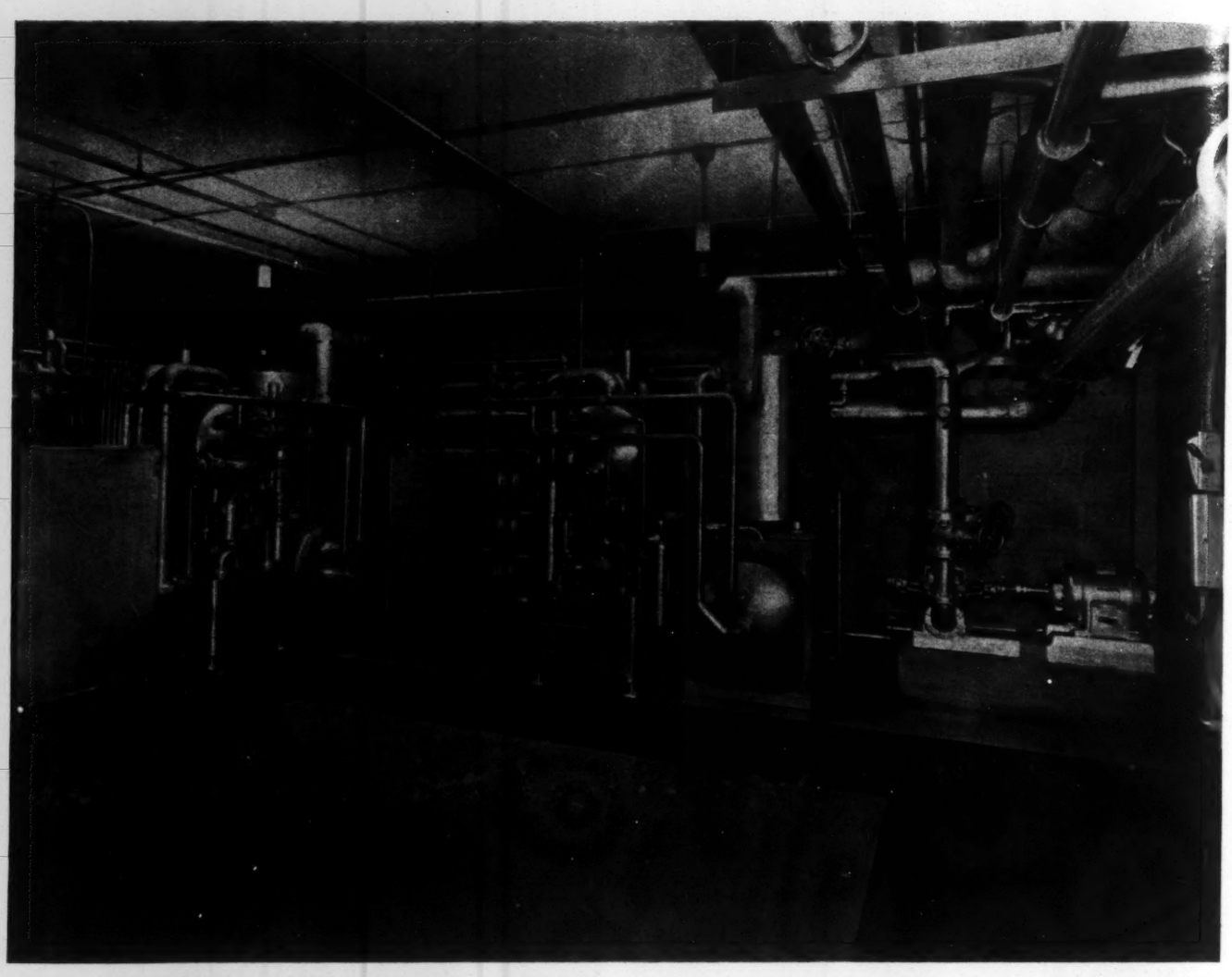
In one tentative proposal submitted by a third manufacturer covering a 315 ton unit for an office building, steam consumption indicated was 21 to 22 lb per ton-

SUMMARY

Progress in the development of absorption refrigeration equipment suitable for air conditioning service is continuing, and the stage of its commercial applicability is within sight. A number of installations have been successfully operated and the range of capacities is being broadened to extend from a two ton minimum rating to upward of 30 tons. An absorption installation aggregating nearly 300 tons peak refrigeration requirement is under construction. . . . In his report at the research committee session at the annual meeting of the National District Heating Association, Mr. Friend amplified the data on absorption refrigeration given in the previous committee report, reviewed the background of the absorption method and outlined its basic principle. He discussed cycles employed in several makes of equipment and general features of apparatus construction, and gave comparisons between absorption and compression systems to indicate fields in which the new development is best suited. . . . The accompanying paragraphs have been taken from Mr. Friend's comprehensive report

*Mechanical Engineer, Ebasco Services, Inc.

Abstract of a paper presented before the research committee session at the 1940 annual meeting of the National District Heating Association



Two of five absorption units installed in the basement of a utility company office building in New Orleans. The group of apparatus in the center consists of one complete unit, comprising from left to right water chiller or evaporator, absorber placed over rectangular heat exchanger on which is mounted the solution pump with its flow regulator, and heater or generator resting on steel framework within which is suspended the condenser. Steam is obtained in this case from existing low pressure gas fired boilers constituting part of the original direct radiation heating system installed in this building

hour, at 230 F (6 lb ga) needed to give a solution temperature of 218 to 225 F. Cooling water requirement named was 5 gpm per ton, with 15 F rise and frictional drop 25 lb. Solution pump power indicated was 28 to 30 hp. However, local circumstances proved such that a centrifugal compressor driven by a steam turbine operated condensing had certain advantages, and contract was awarded to the same manufacturer on this basis.

Assuming steam available at a median rate of 50c per M lb, electric service at 2c per kwhr and city water at $1.50 per M cu ft, absorption refrigeration shows a saving of slightly more than 33 per cent in hourly operating cost for one make of absorption equipment. For equality of costs, rates that may be charged for steam, corresponding to various electric rates, are:

Electric per Kwhr	Steam per M lb
$0.01	$0.39
0.02	0.83
0.03	1.26

Annual maintenance costs and amount of building space occupied by apparatus may be taken as substantially identical. Investment and resulting fixed charges will be approximately the same for both systems, if manufacturer's expectations are realized when quantity production is reached.

Development of absorption refrigeration equipment may be looked for in the future along two lines (1) higher efficiency and output attainable by operating the generator at higher temperature, and (2) higher temperature level for heat rejection to the condensing water, thus decreasing the cost of cooling towers.

In conclusion, summer air conditioning with district steam fuel by means of absorption refrigeration is worthy of encouragement. This kind of apparatus is the equivalent of conventional motor driven compressor units and is adapted to standardization and quantity production when the development stage has been passed. It may be expected to show definite advantages for commercial applications of moderate size.

Although not available for general sale and installation during 1940, some additional absorption installations will be made by utility companies and other concerns this year.

Heating a Garden Apartment Project

Herbert Raisler* Describes the Method of Heating for One of the Suburban or Garden Type Apartment Projects

SUMMARY

Aided by various government and private lending agencies, housing construction is making up for time lost during the depression period of financial readjustment. These projects might be generally classified as suburban or garden type apartments, government subsidized housing projects, moderately sized apartment houses and large multistory apartment buildings. . . . . As an example of the suburban type, the author describes Interlaken Gardens at Eastchester, N. Y. The heating scheme—planned to result in low owning, operating and maintenance costs, flexibility of control and simplicity of operation—comprises a semi-central boiler plant installation. One building in each of the five groups into which the development is divided contains an oil fired boiler plant. From this boiler room, a forced hot water heating system emanates to serve the seven or eight buildings of the group through an underground distribution system. . . . . The control is actuated by an outside thermostat, and incorporates a clock operated night control to maintain 55 F room temperature after a predesignated hour

THE suburban or garden type apartment project aims chiefly to bring to its tenants the advantages of private residence living without the responsibilities of ownership and operation. These apartments are built in sections where only a small part of the land need be used for actual buildings, the remainder being landscaped to allow for minimum tenant congestion and maximum sun and air.

An example of such a project is Interlaken Gardens, Eastchester, N. Y.; the first section of this proposed 3500 family development is now being completed and has been built on 15 per cent of a wooded 40 acre site bordering a lake. It is comprised of 525 apartments divided into 37 two and three story buildings. For heating, the project has been divided into five groups, each having one building designed to contain a boiler plant. A forced hot water heating system emanates from each boiler room, pumping hot water to each of the seven or eight buildings in the group by means of an underground distribution system.

The development contains a total of approximately 80,000 sq ft of direct radiation, placed in all rooms with the exception of kitchens and bathrooms, which are heated by the risers. Narrow tube cast iron radiation is used throughout the apartments so as to occupy a minimum amount of room area. Wall radiators are placed in the various entrance vestibules of the building. The heating system is designed to deliver water at a sufficiently high temperature to maintain 70 F in the rooms when the outside temperature is 0 F.

Each boiler plant contains one Scotch marine type boiler having an oil fired SHBI rating of 30,360 sq ft of radiation. The boilers are provided with copper instantaneous heaters containing 72 sq ft of heating surface for domestic hot water generation. The boiler plant is completely automatic, being fired by horizontal rotary oil burners supplied with No. 6 heavy oil from 5000 gal tanks outside the buildings. At the burner, the oil is mixed with an adequate quantity of air and introduced into the combustion chamber where it is fired by gas-electric ignition. The furnace volume of the boiler is designed so as to have a minimum of 1½ cu ft of combustion space for each boiler horsepower.

Water for the heating system is pumped directly through the boilers by 10 hp direct connected centrifugal pumps set in duplex so as to allow for breakdown service. Approximately 400 gpm of water is circulated against a calculated 40 ft water column head. Between buildings, the steel pipe is run in tile conduit, insulated by packed type insulation. The flow of water is regulated by lock shield gate valves in the branch piping off the distributing mains in the basements of the buildings. These valves are on the return side of the branch piping and control the flow of water to each pair of radiator and heating risers. The piping in the buildings is insulated with air cell insulation.

Expansion in the system due to temperature changes of the water takes place in a closed expansion tank at the ceiling of each boiler room. This tank, in addition to being a safety device, serves as a means of filling the system. The pressure gage on the air cushion of the tank indicates when the highest part of the system has been filled. Excess pressures are relieved by a pressure relief valve.

To maintain low fuel and maintenance costs, a complete set of heating controls is an integral part of the system. Actuated by an outside thermostat, the temperature of the water is regulated according to the load demand on the system. Approximately 240 F water is required to satisfy heating requirements when the outside temperature is 0 F. As the outside temperature increases from 0 to 35 F, the water temperature is correspondingly decreased to 190 F by means of a modulating flame control on the oil burner. This flame control governs the oil flow and the primary and secondary air through the burner so as to maintain a smaller fire in the boiler as the outside temperature increases. The water temperature is further decreased by a three way automatically controlled valve at the outlet of the boiler; this valve functions only after the outside temperature has reached 35 F, and takes control until the outside temperature reaches a point where no heat is required in the buildings. In the valve, sufficient water is bypassed around the boiler to produce a minimum water temperature of 160 F.

The control system also includes a clock operated automatic night control which acts to drop the water temperature at night sufficiently to maintain a 55 F room temperature in the buildings after a predesignated hour set on the control. For rapid morning heating pickup during the winter season, a second clock operated control is used to place the oil burner on maximum flame for as many hours as may be desired in the morning.

*Raisler Corp., Contractors and Engineers.

Heating Abroad and at Home

Sam Lewis* Compares U. S. and English Practice

SUMMARY

Very little heating equipment and practice in the U. S. A. is not paralleled in England, although there are differences. For example, there is an apparent tendency toward the provision of smaller combustion space in mechanically fired boilers there than in this country. Popularity of mechanically circulated hot water heating systems appears to be on the increase in both countries . . . . . English design temperature differences are much less than ours, which may be due to the generally higher outdoor relative humidities there . . . . . Very little is noticed in English magazines about welded ferrous pipe and fittings, or thin walled copper tubing with sweated fittings. Welding equipment serves the American steamfitter in many ways . . . . . Nomenclature used in England differs from that employed in America—"glass wool" is called "glass silk," "pins" are called "needles," "fins" are "gills." Our familiar Scotch marine boiler seems to be known there as the "Economic" boiler, has return tubes around the sides and even below the internal furnace, and usually has two passes instead of one, giving a greater relative overall diameter than that common here

A PERUSAL of the Industrial Heating Engineer, of London, indicates that there is very little equipment and practice in the U. S. A. which is not paralleled in England, although there are differences. I observe an apparent tendency there, for instance, toward the provision of smaller combustion spaces in mechanically fired boilers than is customary in this country. Ability to operate smokelessly and with high efficiency with such small furnaces may be due to a better quality of fuel in England. The popularity of mechanically circulated hot water for industrial heating appears to be on the increase in both countries.

The average design temperature difference in England is very much less than it is here. The generally higher outdoor relative humidity in England probably has much to do with the difference.

I noticed little in the English magazine concerning welded ferrous pipe and fittings or about the very popular American thin walled copper tubing with sweated fittings. Electric welding equipment, and the gas welding and cutting torch, have become useful and economical tools in America. Welding permits attachment to pipes of such things as anchors and sliding hangers allowing for expansion movement, and there is evidence of a welding and cutting torch in the many brackets, standards and pipe rails which one sees around every large American installation.

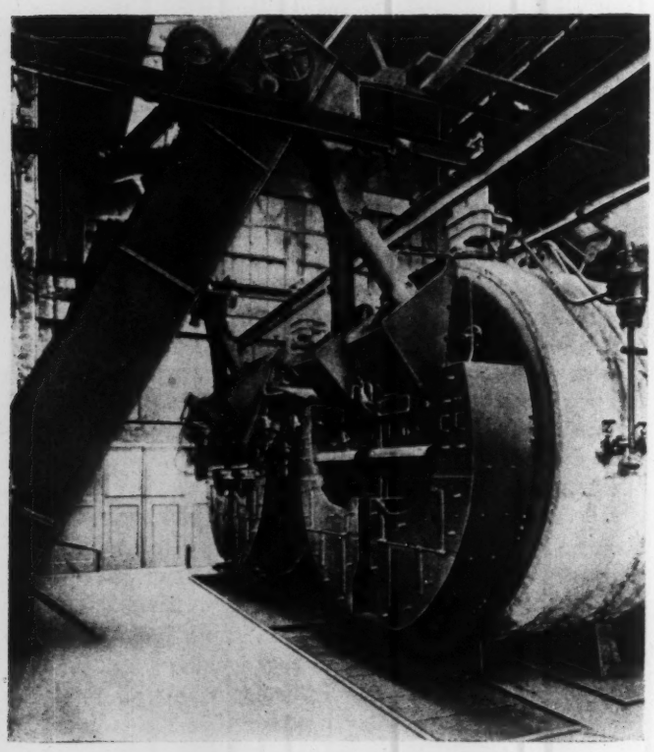
An interesting application of a torch was told me the other day as an evidence of workmen's coöperation. The pit for a 10,000 gal fuel oil tank was being dug by a steam shovel. Some vital part of the shovel broke down when a large boulder was encountered. The steamfitter employed by another contractor made a quick weld and saved the day for the excavator, who in return used the steam shovel as a crane and lowered into the boiler room two heavy tanks for the steamfitter, which lowering otherwise would have required many man-hours.

The nomenclature used in English advertising especially is interesting to an American. For instance, spun glass insulation might be called "glass wool" here, whereas it is called "glass silk" in England. Protuberances on convectors which we call "pins" are "needles" in England. Flanges to increase the heat transferring area of tubes, which we call "fins," are "gills".

Our familiar Scotch marine boiler having a plain or corrugated internal furnace in a heavy shell of large diameter seems to be an "Economic" boiler in England, with the return tubes around the sides and even below the internal furnace. Our Scotch boilers have the breeching connection at the front end, indicating but one pass of the gases through the tubes, but the English boilers illustrated nearly all show two passes, giving a greater relative overall boiler diameter than is common in the U. S. A. Such boilers probably have much larger tubes than the 4 in. outside diameter ones commonly employed in American heating boilers.

*Consulting Mechanical Engineer. Member of Board of Consulting and Contributing Editors.

Our familiar Scotch marine boiler is called an "Economic" boiler in English terminology



Heating · Piping · Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

★ CONTENTS ★

SEPTEMBER, 1940

Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl..... 559

Attenuation of Sound in Ducts of Commercial Size, by R. B. Steffens and W. T. Young... 567

Heating, Ventilating and Air Conditioning Courses 573

Fall Meeting in Houston..... 575

47th Annual Meeting..... 578

Pacific Coast Meeting and Exposition at San Francisco 578

Candidates for Membership..... 580

Candidates Elected 580

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Officers of 31 Chapters are planning fall meeting programs for their members . . . . Houston members are ready for October 14 and 15 and a big Fall Meeting of the Society . . . . Cooperative research is sponsored by the Society in 11 colleges and universities and 22 problems are being studied.

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Development of Instruments for the Study of Air Distribution in Rooms

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This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and conducted at the University of Illinois.

SUMMARY

Air distribution in rooms is a subject now under investigation by the ASHVE Committee on Research, and one phase being studied at the University of Illinois involves the determination of the air velocities and temperatures existing at various points in a representative room, as affected by the location of the supply and exhaust openings, the temperature and velocity of the air at the supply openings, and the temperature outside of the exposed walls of the room.

In this preliminary report the authors describe a wind tunnel which was constructed for the calibration of anemometers over a velocity range from 20 to 2000 fpm. Although nozzle discharge coefficients from different investigations cannot be compared, unless they are calculated on the basis of the same ideal or theoretical discharge, the coefficients from this investigation, based on actual center velocities, agree within ±0.5 per cent with the coefficients for similar nozzles found at the National Bureau of Standards and based on the discharge corresponding to adiabatic flow.

The construction of a heated thermocouple anemometer is described which has certain definite advantages where low velocities are to be measured in a closed space without disturbance due to an observer. The anemometer may be made practically free from directional effects and, by the use of suitable heating currents, it is possible to measure air velocities with satisfactory precision over a wide range, without excessive temperature differences between the air and the heated thermocouple.

THE investigation of the distribution of air in rooms was undertaken to determine the air velocities and air temperatures existing at various points in a representative room, as affected by the location of the supply and exhaust openings, the temperature and velocity of the air at the supply openings, and the temperature outside of the exposed walls of the room. Incident to this investigation it has been necessary to develop some form of anemometer by means of which accurate observations of air velocities over a range of from 20 to 2000 fpm could be made without entering the room, and to perfect a wind tunnel for calibrating such anemometers. This paper constitutes a preliminary report on the construction of the test room, the construction of the wind tunnel and anemometers, and on results obtained from the calibrations of the wind tunnel and anemometers.

Description of Test Plant

Test Room. A complete description of the room heating testing plant, containing the test room to be used for this investigation, has been given in a previous paper.[1] The test room is completely enclosed by a larger structure, having walls, floor and ceiling of 6-in. and 8-in. cork, which forms corridors on three sides of the room, and includes spaces corresponding to an attic and a basement. The walls enclosing the attic and basement spaces are insulated and equipped with cold storage doors, and the spaces are provided with electric heaters, affording means of controlling the temperatures above the ceiling and below the floor of the test room. Refrigerating coils are placed in the front corridor and shielded from the front wall of the test room by means of a baffle, or radiation shield. The three corridors are also provided with electric heaters. The west corridor is equipped with cold storage doors so that it can be isolated from the other corridors. This arrangement, by using the proper combinations of refrigerating coils, electric heaters, and cold storage doors, makes it possible to operate the test room with either two or three walls exposed, and to maintain any desired temperature ranging from —5 F to +110 F in the outside corridors. The temperatures in the attic and basement spaces also can be controlled over a wide range.

The test room alone, without the enclosing corridors, is shown in perspective in Fig. 1. This room is 15 ft wide, 18 ft long, with an 8½-ft ceiling, and the walls are constructed of bevel siding, building paper, sheathing, 3⅝-in. studs, and plasterboard. The front wall contains two 3-ft × 4½-ft double-hung windows, and each of the two side walls contains a similar window and a 3-ft × 7-ft panelled wood door, with 27½-in. × 36-in. glass in the upper portion.

The test room, together with the corridors, the attic and basement spaces, are completely equipped with thermocouples and temperature recorders in order to permit all observations to be made without the necessity for entering the room and thus disturbing conditions at any time during a test. Thermocouples are located at various points in the inside and outside surfaces of the walls, floor and ceiling, as well as at various points in the air in the corridors, in the attic, and in the basement. Similar thermocouples used in connection with the anemometers will be located on a movable rack, spaced so that as the rack is progressively moved, a complete survey of the temperature of the air in the test room at points located approximately 2 ft from one another will be

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[1] ASHVE RESEARCH PAPER—Effect of Room Dimensions on the Performance of Direct Radiators and Convectors, by A. P. Kratz, M. K. Fahnestock, E. L. Broderick and S. Sachs. (ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, July, 1940, p. 439.)

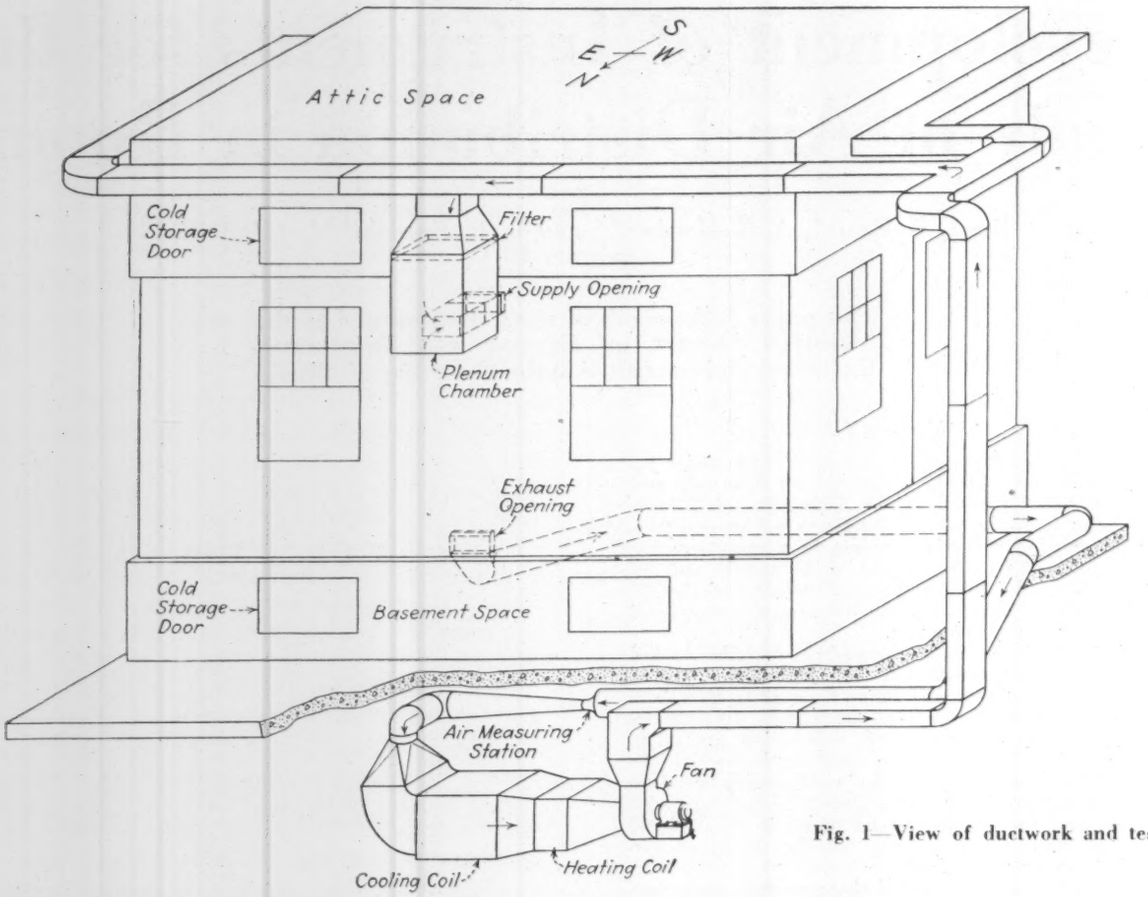

Fig. 1—View of ductwork and test room

obtained. This rack will also carry the anemometers by means of which a simultaneous survey of the corresponding air velocities will be made.

As shown in Fig. 1, air from the air conditioning apparatus is supplied through a vertical riser to a horizontal belt duct located near the ceiling of the corridors, on three sides of the room. The air from this belt duct is admitted to a pendent plenum chamber, from which it is supplied to the supply opening into the room through a short length of horizontal duct extending into the plenum chamber. The plenum chamber can be moved to accommodate different locations of supply openings in the three walls, and the required connections can be made into openings provided in the bottom of the belt duct. The air from the exhaust openings is returned to the air conditioning apparatus through a 10-in. round duct, which can be adjusted in the basement space to accommodate the various required locations of the exhaust openings. Fig. 1 shows the arrangement with a supply opening 7 ft above the floor in the central axis of the front wall, and with an exhaust opening directly under the supply opening and in the center of the baseboard of the front wall. All portions of the ducts located in what may be cold spaces are insulated with 3-in. cork, while those portions not subjected to extreme temperatures are insulated with 1-in. rigid fiber insulation.

Air Conditioning Apparatus. The air necessary to maintain the required conditions in the room and the required velocities and temperatures at the supply openings is conditioned by apparatus located as shown in Fig. 1. The room, duct work, and air conditioner, form a closed circuit. The air conditioning plant, as shown in Fig. 1, consists of appropriate heating and cooling coils, a fan, and a motor-driven condensing unit.

Cooling is accomplished by passing the air over extended surface coils through which chilled water is circulated. The temperature of the water entering the coil is regulated by means of a three-way mixing valve controlled by a thermostat located in the duct furnishing air to the supply openings. Chilled water is obtained from a reservoir containing a direct expansion coil connected to the condensing unit. By using a modulating expansion valve, and by adjusting the speed of the compressor to give a capacity approximately equal to the cooling load on the test room, intermittent operation of the condensing unit may be avoided, and the water in the reservoir may be maintained at a constant temperature appropriate for use at the three-way mixing valve.

Heating is accomplished by passing the air over extended surface coils supplied directly with steam from the laboratory main. The air temperature is regulated by means of a valve in the steam line to the coil, which is controlled by a thermostat located in the duct furnishing air to the supply openings.

The amount of conditioned air circulated is measured by means of a calibrated nozzle located in the exhaust line just before the coils, as shown in Fig. 1.

Test Conditions

Cooling. The plant has been designed to provide for a maximum cooling load of 29,650 Btu per hour, based on an outdoor temperature of 110 F, an indoor temperature of 70 F, one air change per hour ventilation, six occu-

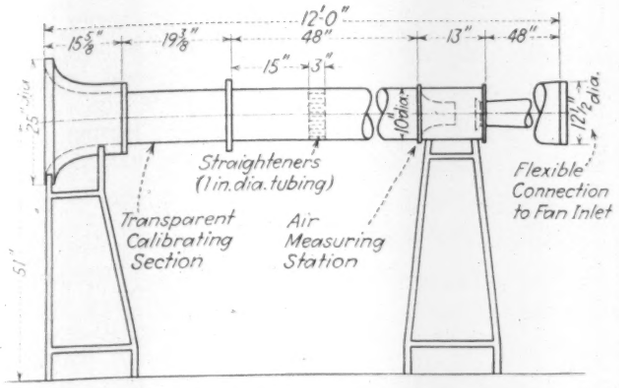

Fig. 2—Wind tunnel for calibration of anemometers

Table 1—Dimensions of Nozzles with Elliptical Approach

	Throat Diameter In. d	Semi-Major Axis — In. $a = d$	Semi-Minor Axis — In. $b = 2/3\ d$	Length of Throat In. c
National Bureau of Standards D-1 Nozzle.....	1.764	1.764	1.176	1.764
National Bureau of Standards B-2 Nozzle.....	4.521	4.520	3.013	2.260
National Bureau of Standards C-2 Nozzle.....	5.003	5.000	3.333	2.500
University of Illinois Small Nozzle.....	1.764	1.764	1.176	1.764[a]
University of Illinois Large Nozzle.....	4.250	4.250	2.833	2.125
University of Illinois Rounded Entrance..	10.010	10.000	6.667	———a

[a]Note: The entrance throat is continued into the calibrating section by a smooth connection.

pants using computing machines, and lights to the amount of 1350 w. Under these conditions it will require 36.5 recirculations per hour, with the air leaving the supply openings at 50 F. By adjusting the size of the supply openings, velocities varying from 400 to 1200 fpm may be obtained.

Most of the studies will be made on a normal design load of 6,500 Btu per hour, based on an outdoor temperature of 95 F, an indoor temperature of 80 F, no ventilation except by infiltration, and no occupancy or lights. Under these conditions it will require 10 recirculations per hour, with air leaving the supply openings at 65 F. Velocities varying from 400 to 1200 fpm at the supply openings will be used.

Heating. The plant will provide for a heating load of 27,670 Btu per hour based on an outdoor temperature of 0 F and an indoor temperature of 75 F. Normally studies will be made with the air leaving the supply openings at a temperature of 135 F and velocities varying from 400 to 1200 fpm. Studies may be made with air leaving the supply openings at temperatures varying from 95 to 150 F.

Instruments and Methods of Measurement

Wind Tunnel and Measuring Instruments. The range of air velocities to be measured extends from velocities as low as 20 fpm to 2000 fpm. Such a range, as well as the fact that the anemometer measurements must be made without disturbing conditions in the test room, restricted the choice of an instrument to some type of thermal anemometer. The instrument finally selected was a heated thermocouple, somewhat similar to that developed by Hukill[2] for measuring thermal air currents of very low velocities. The principal advantage of such an anemometer over a hot-wire anemometer, is that measurements may be made with a number of separate instruments and a single potentiometer, without the necessity of elaborate switching arrangements.

Fig. 2 is a line drawing of the apparatus for calibrating the anemometers. It consisted of a small draw-through wind tunnel, following the design used by Tuve.[3] The calibrating section was a 20-in. length of transparent duct, 10 in. in diameter, into which air flowed through a bell-mouthed entrance. The principal dimensions of this entrance, which had an elliptical approach, are given in Table 1. Following this section was a 48-in. length of 10-in. sheet metal duct leading to the measuring section, containing the measuring nozzle. From this latter section an expanding sheet metal section 48 in. long led to the inlet of the fan, which drew air through the tunnel. Since all air velocity determinations were to be based on flow measurements at nozzles calibrated by Pitot tube explorations, the measuring section of the wind tunnel was arranged so that the nozzles could be positively located with respect to the tunnel and that accurate pressure explorations could be made across the outlet of the nozzles. The expanding section, between the measuring section and the fan inlet, reduced the resistance of the system by allowing the conversion of dynamic pressure into static pressure to take place with a minimum loss due to shock and turbulence.

The fan was belt driven by a compound wound direct current motor, so that partial control of the rate of flow in the tunnel was obtained by varying the speed of the motor. A sliding damper attached to the fan outlet provided additional control.

In Fig. 3 details of the measuring section are shown. This section was made of a piece of 10-in. steel pipe to which flanges were welded for connecting to the preceding and following sections of sheet metal duct. Two nozzles, one with a throat diameter of 4.250 in. and one with a diameter of 1.764 in. were required to make measurements throughout the chosen velocity range. Both nozzles were elliptical in shape, the larger being similar to the *B*-2 and *C*-2 nozzles used by Bean, Buckingham and Murphy in their investigation at the National Bureau of Standards,[4] while the smaller nozzle was identical with the *D*-1 nozzle used in the same investigation. The principal dimensions of the nozzles are given in Table 1. The nozzles, which were cast of aluminum, were carefully machined and polished. They were located in the measuring section so that the end of either nozzle would lie in the same plane. Thus, the stream issuing from the nozzle could be traversed at the end of the nozzle by small exploring impact and static pressure tubes. Instead of measuring the drop in pressure, by means of pressure taps in the wall of the duct before and after the nozzle, the difference between the static pressure, as measured with a piezometer ring at the end of the nozzle, and the impact pressure, as measured with a

[2]An Anemometer for Measuring Low Air Velocities, by W. V. Hukill. (*Refrigerating Engineering*, Vol. 28, 1934, p. 197.)

[3]ASHVE Research Report No. 1140—The Use of Air-Velocity Meters, by G. L. Tuve and D. K. Wright, Jr. (ASHVE Transactions, Vol. 45, 1939, p. 645.)

[4]Research Paper No. 49. *Bureau of Standards Journal of Research*, Vol. 2, 1929, p. 561.

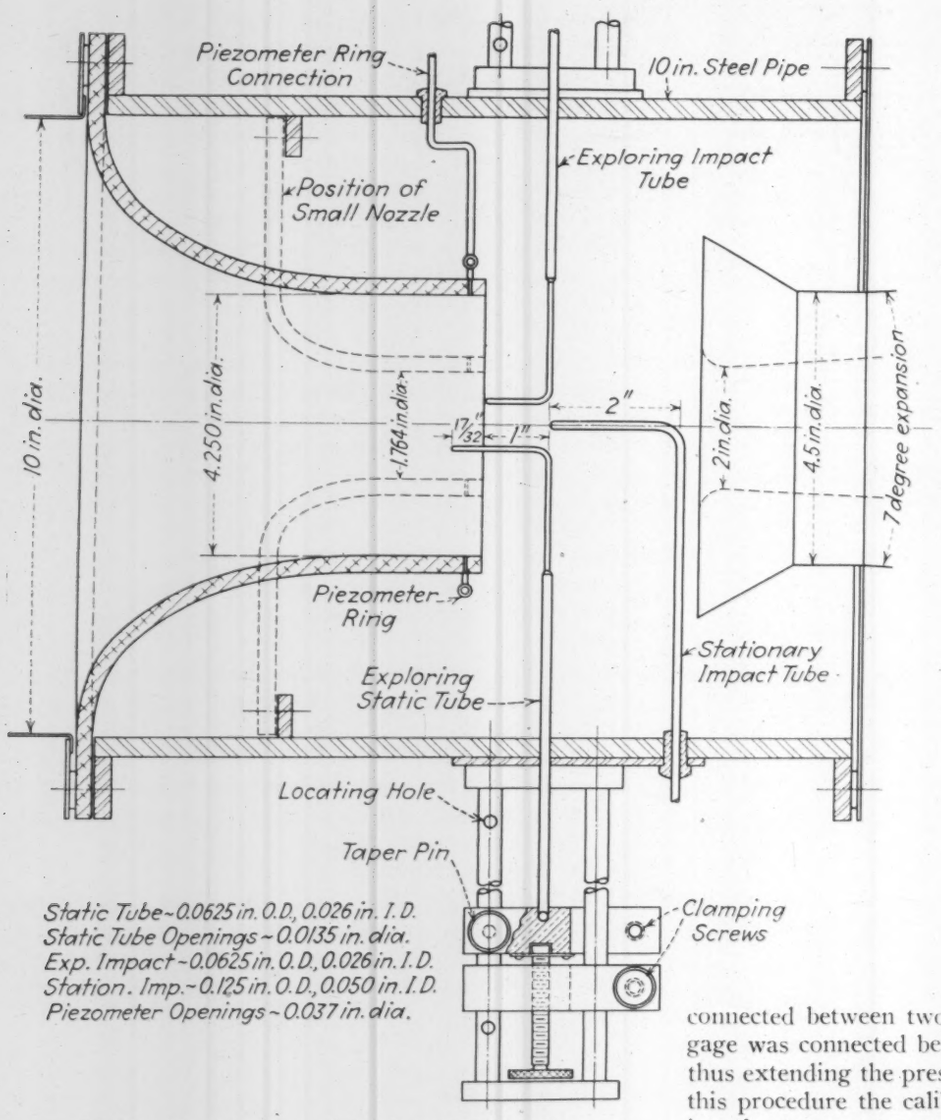

Fig. 3—Air measuring station for wind tunnel

stationary impact tube, was observed. The piezometer ring was made of ⅛-in. brass tubing which connected four 0.037-in. diameter holes drilled through the nozzle wall 0.25 in. from its end. The stationary impact tube also was made of ⅛-in. brass tubing, with dimensions similar to those of the ASHVE Standard Pitot tube. This tube was located at the axis of the nozzle and slightly more than 1 in. from the nozzle end.

The static pressure exploring tube was exactly similar to the Pitot tube and was so located that the four 0.0135-in. diameter holes, which formed the static pressure openings, were at the end of the nozzle. The impact pressure tube was also similar to the Pitot tube, except that the length of head was 1 in., or 16 diameters. With this length of head, the opening in the end of the tube would be at the end of the nozzle when the stem of the impact tube was placed in a position corresponding to that of the static pressure tube. The two exploring tubes were made of 1/16-in. brass tubing which, for increased stiffness, was sweated into ⅛-in. tubing 2 in. from the head of the tubes. By means of two movable heads sliding on guide rods, the exploring tubes could be moved across the end of the nozzle and accurately located at its center, or at either wall, by means of a taper pin placed in any one of a series of reamed holes in one of the guide bars. From these reference locations, the tubes could be moved to intermediate positions by means of a micrometer screw. Thus the position of the tubes across the end of the nozzle could be established within ±0.001 in. along either a vertical or horizontal diameter. All pressure measurements were made either with a Wahlen gage or with commercial inclined manometers, calibrated against the Wahlen gage. The apparatus for calibrating the manometers was similar to that suggested by Ower[5] and consisted of three large glass bottles placed in an insulated box. Very constant pressure differences could be produced by pumping air from one bottle to another. Direct comparison of the pressures, as measured with the Wahlen gage and an inclined manometer, was made up to 0.8 in. of water, the limit of the Wahlen gage. For higher pressures, a manometer calibrated to 0.8 in. was connected between two of the bottles, while the Wahlen gage was connected between the second and third bottle, thus extending the pressure range to 1.5 in. of water. By this procedure the calibration of the manometer up to 2 in. of water was accomplished. Since all errors in the inclined manometer reading were less than 1 per cent at a pressure of 2 in. of water, the calibrations were not extended to higher pressures.

Air Velocity Measurements. The small nozzle, with a throat diameter of 1.764 in., was calibrated over a range of piezometer-impact pressure differences extending from 0.04 to 9 in. of water while the large nozzle, with a throat diameter of 4.250 in. was calibrated for a pressure range of 0.25 to 7 in. of water. The velocity range in the 10-in. diameter calibrating section with the small nozzle was from 25 to 380 fpm and with the large nozzle from 360 to 2000 fpm.

The velocity distribution across a section following a convergence with a well-formed approach, such as that of a nozzle with an elliptical profile, is so nearly uniform that the nozzle coefficient is largely determined by the velocity distribution close to the wall of the nozzle. For this reason the usual method of Pitot tube traverse, which consists of measuring the velocity pressure in a number of concentric zones of equal area, is unsatisfactory unless the section is divided into an extremely large number of zones. A more convenient procedure is to space the

[5]Measurement of Air Flow, by E. Ower. (*Second Edition*, 1933, p. 187).

pressure measurements inversely as the steepness of the velocity profile. The velocities, calculated from the velocity pressures, are then weighted by the square of the corresponding radii, and the average velocity is their sum divided by the square of the radius of the section. This result may also be readily obtained by plotting the velocities against the square of their corresponding radii and measuring or calculating the area under the resulting curve.

With an exploring impact tube 1/16 in. in diameter, and having an opening of 0.026 in., it was impossible to make satisfactory impact pressure measurements closer to the wall than 0.015 in. Even at greater distances from the wall, the readings were rather questionable, due to the extremely steep velocity profiles, especially with those which existed at the higher velocities. In order to extrapolate the velocity distribution in some systematic manner, from the region where reliable measurements could be made down to zero velocity at the wall, von Kármán's[6] analysis of turbulent flow at the wall of a pipe was applied to the flow at the nozzle wall. First the thickness of the laminar boundary was calculated from the relation

$$\delta = \frac{767.5\,R}{\left(\frac{RU_c}{\nu}\right)^{7/8}} \qquad (1)$$

in which δ is the thickness of the laminar layer in inches, R is the radius of nozzle throat in feet and $\frac{RU_c}{\nu}$ is Reynolds' number based on the center velocity, U_c, in fps and the characteristic length R. The ratio of the velocity at the laminar boundary, $U\delta$, to the center velocity was found from

$$\frac{U\delta}{U_c} = \frac{2.11}{\left(\frac{RU_c}{\nu}\right)^{1/8}} \qquad (2)$$

and the velocity in the laminar boundary layer was assumed to vary linearly from $U\delta$ to zero velocity at the wall. Within the turbulent boundary layer, the velocity was represented with a fair degree of accuracy by the dimensionless relations:

$$\sqrt{\frac{U}{\frac{\tau_o}{\rho}}} = 11.0 \log \sqrt{\frac{\tau_o}{\rho}\cdot\frac{y}{\nu}} \qquad (3)$$

for the small nozzle and

$$\sqrt{\frac{U}{\frac{\tau_o}{\rho}}} = -2.2 + 13.0 \log \sqrt{\frac{\tau_o}{\rho}\cdot\frac{y}{\nu}} \qquad (4)$$

for the large nozzle. In these expressions, τ_0 is the constant shearing stress in the laminar region found from

$$\sqrt{\frac{\tau_o}{\rho}} = 0.0862\,U\delta \qquad (5)$$

δ is the mass density in slugs per cubic foot and ν the kinematic viscosity in feet^2 per second, while y is the distance from the wall in feet. The constants in Equations (3) and (4) differ considerably from those in the von Kármán equation, the slope in the latter equation being approximately half that of either of the former. However, such results were to be expected, since the conditions of flow in the turbulent boundary layer in the nozzles corresponds to that in the transition region between the laminar boundary and the turbulent boundary in fully established turbulent flow in a pipe.

The agreement between the measured velocities and those calculated on basis of the von Kármán analysis was best at the lower velocities and thicker boundary layers, when measurements could be made down to and, in a few tests, into the laminar layer. For this reason the method was used to obtain the velocity distribution in the boundary region for all of the nozzle explorations. From the complete velocity profile the average velocity and rate of discharge could be found as previously described.

Since the discharge coefficient of a nozzle is the ratio of the actual discharge to some theoretical or ideal discharge, if coefficients from different investigations are to be compared, they must be calculated on the basis of the same ideal discharge. When the drop in static pressure across the nozzle is measured, the theoretical discharge is usually that corresponding to frictionless, adiabatic flow for the given pressure differential. But if the differences in static pressures are determined by measurements at taps, located in the wall of the pipe, up stream and down stream from the nozzle, the resulting discharge coefficients are not strictly comparable unless the pressure measuring taps have identical locations and the conditions of flow, both before and after the nozzle, are duplicated. The discharge coefficients for the nozzles used in the present investigation were calculated on the basis of the discharge corresponding to a uniform velocity equal to the actual center velocity, as measured with the exploring impact and static pressure tubes. The center velocity, determined in this manner, should be very nearly equal to that of frictionless adiabatic flow for the static pressure differential which actually exists at the center of the nozzle. However, due to variations in static pressure which may exist across the stream issuing from the nozzle, the center velocity may differ slightly from the frictionless adiabatic flow velocity, calculated from the pressure differential measured by wall pressure taps.

Comparison of nozzle discharge coefficients is facilitated by plotting them against Reynolds' number as shown in Fig. 4. The plotted points are the coefficients for the two nozzles under discussion, while the broken

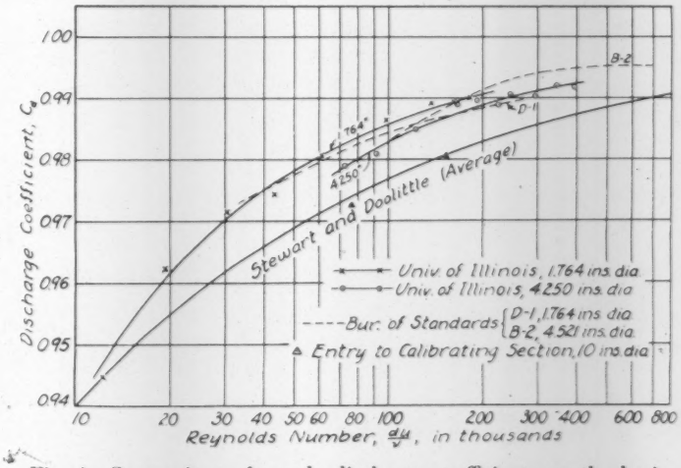

Fig. 4—Comparison of nozzle discharge coefficients on the basis of Reynolds' number for air at 70 F and 29.92 in. hg

[6]Fluid Mechanics for Hydraulic Engineers, by H. Rouse. (*First Edition*, 1938, p. 238.)

lines represent the coefficients for two National Bureau of Standards[7] nozzles, one slightly larger than the large nozzle and the other identical with the small nozzle. From these curves, it is evident that the coefficients for the nozzles used in this investigation agree with the corresponding Bureau of Standards coefficients well within the limits of experimental error. The lower full line in Fig. 4 represents the average coefficients from a large number of tests by different investigators, using different fluids and various types of nozzles and orifices with gradual approach transitions, as given by Stewart and Doolittle.[8] They state that coefficients, obtained from various sources, showed such lack of agreement, particularly at flow with small Reynolds' numbers, that a curve which represents average values only, can be drawn. Such lack of agreement is, at least partly, due to the effect of the type of approach used and to the location at which pressure measurements were made; because the agreement between the coefficients from the present investigation and those given by the National Bureau of Standards investigation, indicates that the coefficients of similar nozzles are reproducible within ±0.5 per cent.

With nozzle coefficients based on center velocities, the average velocity, or the discharge from a nozzle, cannot be determined unless the relation between the center velocity pressure and the pressure drop across the nozzle has been established. Even the pressure difference between a central impact tube and a piezometer ring at the wall of the nozzle, does not give the true center velocity pressure on account of the variation in static pressure across the stream as it issues from the nozzle. It was necessary, therefore, to find the ratio between the true center velocity pressure, as measured with the exploring impact and static pressure tubes, and the pressure difference between the stationary impact tube and the piezometer ring. For the small nozzle, this ratio was found to vary from 0.992, at a piezometer pressure of 0.2 in. of water, to 0.994 at a pressure of 6 in. Over the same piezometer pressure range, this ratio for the large nozzle was found to vary from 0.980 to 0.989.

The variation of static pressure across the stream at the end of the nozzle is probably the result of the variation in the centripetal force which must be exerted to produce flow along paths of varying curvature into the throat of the nozzle. This change in static pressure has been observed by other investigators[9] and has been discussed analytically by Kretzschmer[10] as a problem in potential flow. An attempt to predict the magnitude of such pressure variation, on the basis of the dynamics of flow, was unsuccessful, but the problem is still under consideration.

The average velocity in the 10-in. diameter calibrating section is related to the average nozzle velocity by means of the continuity equation. However, in calibrating small anemometers, the center velocity at the calibrating section must be known and this requires the determination of the discharge coefficients for various rates of flow out of the bell-mouthed entrance into the calibrating section. Such discharge coefficients were found by impact and static pressure tube explorations, with velocities of 890 and 1800 fpm through the section. The small exploring tubes, used in the calibration of the nozzles, were used for these explorations and the resulting coefficients were found to agree rather well with the Stewart and Doolittle curve for average coefficients, as shown in Fig. 4. Extrapolation, by means of such a curve, to obtain discharge coefficients with flow at low Reynolds' numbers, is a rather questionable procedure, in view of the disagreement between the available experimental results. However, the difficulty of accurately measuring velocity pressures under these conditions precludes the use of any other method. Certainly coefficients, obtained in this manner, are preferable to a constant coefficient for the entire velocity range.

Table 2—Comparison of Velocities in Calibrating Section from Pitot Tube and Nozzle Measurements

Pitot Tube Size and Type of Manometer	Piezometer, Impact Pressure Difference In. of Water	Center Velocity at Calib. Section, Calculated Fpm	Pitot Tube Velocity Pressure at Calib. Section In. of Water	Center Velocity at Calib. Section (Pitot Tube) Fpm	Velocity Difference in Per Cent of Measured Velocity
5/16" ASHVE Standard Wahlen Gage	0.30	412.7	0.0104	416.4	0.89
5/16" ASHVE Standard Wahlen Gage	0.80	671.1	0.0274	686.1	2.19
5/16" ASHVE Standard Wahlen Gage	1.20	822.2	0.0404	836.4	1.70
5/16" ASHVE Standard Wahlen Gage	1.80	1005	0.0601	1014	0.89
5/16" ASHVE Standard Wahlen Gage	2.20	1113	0.0735	1124	0.98
5/16" ASHVE Standard Wahlen Gage	2.95	1287	0.0983	1299	0.92
5/16" ASHVE Standard Inclined Gage	1.80	1012	0.0625	1023	1.08
5/16" ASHVE Standard Electronic Gage	1.80	1012	0.0632	1029	1.65
5/16" Exploring Tube Wahlen Gage	1.80	1012	0.0626	1027	1.46

As a final check on the accuracy of the several coefficients involved, comparisons were made of the center velocity, measured at the calibrating section by means of a Pitot tube, with the corresponding velocity calculated from the pressure difference at the nozzle. A summary of the results of these measurements is given in Table 2. As indicated in this table, velocity pressures at the calibrating section were measured with an ASHVE standard Pitot tube and with the $\frac{1}{16}$-in. exploring tubes, using both the Wahlen gage and a calibrated inclined manometer. For velocities greater than 750 fpm, the velocity, as measured with the Pitot tube, was consistently from 1 to 1.5 per cent higher than that found from the nozzle measurements. At lower velocities, the Pitot tube measurements became increasingly uncertain, because of the effect of pressure fluctuations when very small pressure differences were being measured. This condition was so pronounced when measurements were made using the small nozzle, that no consistent results could be obtained.

Although a number of possible reasons for this disagreement between the Pitot tube and nozzle measure-

[7]Loc. Cit. Note 4.
[8]Fluid Flow Measurement, by F. C. Stewart and J. S. Doolittle. (*Instruments*, Vol. 12, 1939, p. 175.)
[9]Nusselt. Zeit, F. Flugtechn., Vol. 6, 1915, p. 179. Jakob and Erk, V. O. I. Forschungsheft, 1924, No. 267.
[10]Stromungsform u. Durchflusszahl d. Messdrosseln, F. Kretzschmer, Forschungsheft, 1936, No. 381.

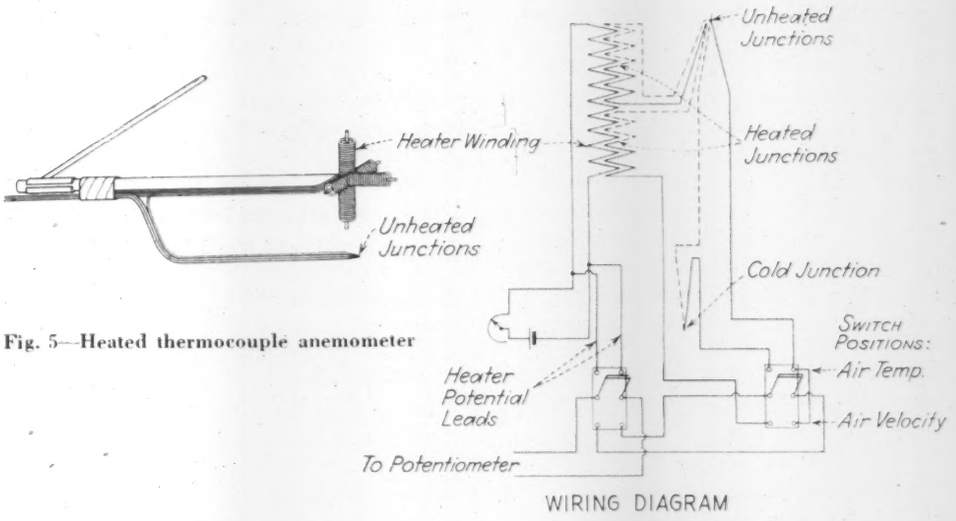

Fig. 5—Heated thermocouple anemometer

ments were considered, as for instance the effect of compressibility in the flow equation and in the continuity equation, and the effect of pressure fluctuations on the Pitot tubes and manometers; none seemed sufficient to account for an error of this magnitude. It was finally concluded that the most likely source of such an error was in the determination of the discharge coefficient for the calibrating section and, until explorations can be made at this section with some form of small thermo-anemometer, no further conclusions are possible.

Heated Thermocouple Anemometer. Some of the more desirable characteristics in an anemometer for the proposed study of air distribution are the following:

1. The instrument should be remote reading, so that air velocity measurements can be made without the observer entering the room.
2. The instrument should measure the velocity across a section of approximately the same proportions as that measured by the standard Pitot tube.
3. The range of velocities, throughout which the instrument is sensitive, should be from 20 to 2000 fpm.
4. The instrument should have a minimum directional response.
5. Duplication of the instrument should be relatively easy.

In Fig. 5 is shown the final design of heated thermocouple, which was developed to meet the requirements specified. The wiring diagram of the thermocouple and heater circuits is also shown in Fig. 5.

The frame of the anemometer consists of three ½-in. pieces of No. 24 brass or steel spring wire, soldered together so as to be mutually perpendicular. One of the wires was cemented into a hole drilled in the end of a piece of round rawhide belt lacing, which forms the support for the anemometer. The thermocouples were made from No. 34 B. & S. gage copper and constantan wire. Enamel insulated wire was used and, after the lap soldered couples had been made, the wire was given two coats of insulating lacquer. The electric heater was made of No. 34 B. & S. gage enameled, constantan wire, which was also given two coats of insulating lacquer before being wound. The heater and thermocouple wire were wound side by side on the wire prongs, 28 turns on the center prong and 18 turns on each of the side prongs. Two heated and two unheated thermocouples were used. These couples were connected in series, in order to increase the electro-motive force due to the temperature difference between the heated and unheated thermocouples. As indicated in the wiring diagram, Fig. 5, one of the unheated junctions of the anemometer was soldered directly to a copper-constantan junction made of No. 24 wire, while the other unheated anemometer junction was cemented to, but insulated from, the large junction by means of insulating lacquer. The anemometer electro-motive force was measured between the copper lead from the anemometer junctions and the copper lead from the No. 24 wire junction. The electro-motive force between the No. 24 wire leads indicated the temperature of the air close to the point where the velocity measurement was being made.

The anemometer heater was supplied with current

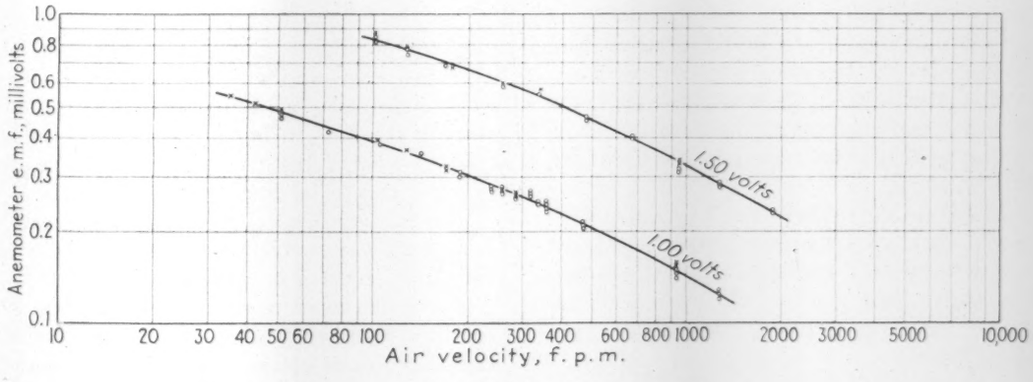

Fig. 6—Calibration curves for heated thermocouple anemometer

from several dry cells and a rheostat was used to control the current. The potential drop across the heater was measured with the potentiometer which was used in measuring the electro-motive force of the anemometer thermocouples.

Calibration of Heated Thermocouple Anemometer. The calibration curves in Fig. 6 show the air velocity plotted on logarithmic coordinates against electro-motive force difference between heated and unheated anemometer junctions. From these results it is clear that, although velocity measurements could be made over the entire range, with the same heater voltage, it was desirable to use three or four different voltages throughout the range. With potentials of 0.75, 1.00 and 1.5 volts it was possible to measure velocities from 20 to 2000 fpm with satisfactory precision and without excessive temperature differences between the heated and unheated thermocouples. If the velocity range was not too great for a given voltage, the calibration curves were found to be straight lines having a slope of approximately 2.6. The wire prongs, which extended beyond the heater coils, were trimmed in order to balance the heat loss; so that the electro-motive force measured when the axis of the anemometer was parallel to the direction of flow, agreed with the electro-motive force measurement when the flow was perpendicular to the axis. Plotted points in Fig. 6 indicate that the difference in electro-motive force in these two positions may be reduced to the order of magnitude of the random experimental errors. However, it should be noted that, due to the steepness of the calibration curves, the velocity measurements with the heated thermocouple anemometer have only about half the accuracy of the corresponding electro-motive force measurements.

Summary of Results

This paper describes a wind tunnel which was constructed for the calibration of anemometers over a velocity range from 20 to 2000 fpm. All velocity measurements are based on flow measurements with two elliptical approach nozzles, which were calibrated by means of small exploring impact and static pressure tubes. Although nozzle discharge coefficients from different investigations cannot be compared, unless they are calculated on the basis of the same ideal or theoretical discharge, the coefficients from this investigation, based on actual center velocities, agree within ±0.5 per cent with the coefficients for similar nozzles found at the National Bureau of Standards and based on the discharge corresponding to adiabatic flow.

The discharge coefficients for the calibrating section of the wind tunnel were found from Pitot tube measurements in the velocity range where such measurements could be made with sufficient accuracy. The coefficients for velocities below this range were found by extrapolation on the basis of Reynolds' number, using a curve representing nozzle discharge coefficients, with which the measured coefficients were in good agreement at the higher velocities.

The construction of a heated thermocouple anemometer is described which has certain definite advantages where low velocities are to be measured in a closed space without disturbance due to an observer. The anemometer may be made practically free from directional effects and, by the use of suitable heating currents, it is possible to measure air velocities with satisfactory precision over a wide range, without excessive temperature differences between the air and the heated thermocouple.

Acknowledgments

The data presented in this paper were obtained in connection with an investigation sponsored by the American Society of Heating and Ventilating Engineers and conducted by the Engineering Experiment Station of the University of Illinois. This work is carried on in the Department of Mechanical Engineering. The results will ultimately comprise part of a bulletin of the Engineering Experiment Station.

The assistance of interested manufacturers in contributing to a special fund for this work is acknowledged with appreciation by the Technical Advisory Committee on Air Distribution and Air Friction.

Air Conditioned Cars for Commuters

A new suburban service has been instituted by the New York, Susquehanna and Western R.R. for Northern Jersey to Times Square points, and recently the first air conditioned suburban train was placed in service. The streamlined car seats 80 persons and was designed by the American Car and Foundry Co., St. Charles, Mo. The air conditioning system designed by Herbert Ewer has several novel features. The power plant and the complete heating and cooling system are located below the floor of the car, so that there is a clear unobstructed view from end to end.

This car has a 290 hp supercharged oil engine which drives through a twin disc clutch and torque converted to an axle drive on one set of wheels. It has six cylinders, a bore of 6¼ in. and a stroke of 6½ in. The engine produces the maximum hp at its maximum governed speed of 1800 rpm.

A special pneumatic control apparatus decides whether the car is to be cooled in warm weather, ventilated, warmed by electricity, or heated from the engine exhaust in cold weather. The thermostat operates in response to outside temperature and inside humidity. An entirely new departure in air circulation includes a dual set of ducts. Cold air is delivered along a center overhead duct, and returned along the sides at the floor level. Hot air, on the other hand, is delivered by reversing the fans, using the floor-level ducts for delivery and the overhead duct for return. The design permits half the car to be occupied by smokers.

The car can get up to 60 mph in about two minutes. It is readily possible to design this type car for higher speeds by control of the gearing.

The ends accommodate five windows which give the operator excellent vision around the entire front of the car. Both ends of the car have been made the same, so that the car operates in either direction.

Attenuation of Sound in Ducts of Commercial Size

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SUMMARY

Recognizing the air conditioning engineer's need for a simple and practical method of showing the sound attenuation of each of the elements of any duct system, research was undertaken to develop data which would be applicable to the usual ventilating and air conditioning system. A new test method was developed which provides for the measurement of sound attenuation from the change in sound level in a receiving room of average room characteristics with change in length of the duct discharging sound into the room. The series of tests covered the relationship of sound attenuation to flue size, the shape and absorbing characteristics, using ducts of commercial size. The need is shown for further investigation of ducts of different sizes, types and constructions and need for determining accurate figures for the attenuation of sound as it passes through fittings and other items used in the construction of the average air duct installation.

Introduction

THE expanding use of air ducts in modern air conditioning systems has increased the importance of investigating methods of minimizing the noises which are caused by operation of such systems. Noise created by fans and motors and by the high velocity air passing over irregularities in the system is transmitted to rooms mainly through the supply and return air ducts. Accordingly a study of the attenuation of sound in air ducts of commercial size is important.

For obvious reasons of cost, the average duct installed for air conditioning is not lined with acoustical lining. The length of the individual duct run varies from a few feet up to a hundred feet or more. A duct run may ordinarily include dampers, turns, transformations, take-offs, and outlets of wide variety. Ideally, the air conditioning engineer should have available a table showing the sound attenuation in each of the elements of any system, and by simple addition should be able to predict the sound level in any room caused by the conditioning system. As indicated by the references cited, there is a paucity of acoustical data applicable to the usual conditioning system. The lack of data may be chiefly ascribed to the fact that air conditioning systems are highly resonant, and attempts to measure the average level of sound in even a straight run of metal duct merely shows the enormous variations in sound intensity of the standing wave system that may occur along the duct.

This phenomenon is unfortunate, as there are many elements of a duct system that do attenuate sound. There is a large drop in sound level from the plenum chamber to the duct entrance, a similar drop from the outlet to the rooms, smaller drops in elbows, transformations, and take-offs, at dampers, and even along the straight runs, but the values are not known. In the present state of the art, the engineer may empirically line a few feet of the duct at the plenum chamber end of the duct system with acoustical lining. This is usually fairly satisfactory, and in combination with some lining applied with more difficulty near the outlets, will provide at least a partial solution of the sound problems involved. This method has the disadvantage of being somewhat costly, and the amount of treatment required is rarely known even approximately.

Development of a Practical Test Method

This paper presents a method of determining sound attenuation that appears to be readily applicable to the measurement of sound attenuation in any element or combination of elements of an air conditioning system.

A few investigators have given some attention to the problem of calculating attenuation of sound in ducts, but with few exceptions, they have worked with ducts lined with highly sound absorbing linings, and in order to avoid the confusing effects of standing wave patterns, have worked with sound of single frequency and with ducts, the characteristics of which are not typical of those commonly used.[1, 2, 3, 4] In addition, the derived formulae are not readily adaptable and in most cases are not applicable, to calculation of the acoustical characteristics of typical ducts. Heilman and MacArthur[5] used an adaptation of the two-room method where the sound levels in two small rooms connected by a fixed length of duct were measured, one of the rooms containing a sound generator. This method is limited in scope, as the duct was of fixed length, and the room remote from the sound generator was not an average room. There is another marked limitation in their method in that there is no way to differentiate between the sound attenuation at the entrance and exit of the duct and that in the duct itself. In order to overcome the many difficulties and inaccuracies of the probe methods of measuring sound attenuation, a modification of the two-room method was used in this investigation.

The new test method, shown in Fig. 1, provides for the measurement of sound attenuation from the change in sound level in a receiving room of average room characteristics with change in length of the duct discharging sound into the room. Thus, an increase in length of duct causes increased sound attenuation and thereby reduces the amount of sound discharged into the receiving room. If sound of constant intensity is

*A portion of the work covered in this paper appears in a thesis submitted by R. B. Steffens to the Faculty of the College of Engineering and Commerce, University of Cincinnati, in partial fulfillment of the requirements for the degree of Commercial Engineer, June, 1940.

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[1] P. M. Morse, *Journal, Acoustical Society of America*, 11, 205, 1939.
[2] L. J. Sivian, ibid, 9, 135, 1937.
[3] Taylor and Sherwin, ibid, 9, 331, 1938.
[4] Robert Rogers, ibid, 11, 481, 1940.
[5] Performance Tests of Asbestos Insulating Air Duct, by R. H. Heilman and R. A. MacArthur. (ASHVE Transactions, Vol. 44, 1938, p. 197.)

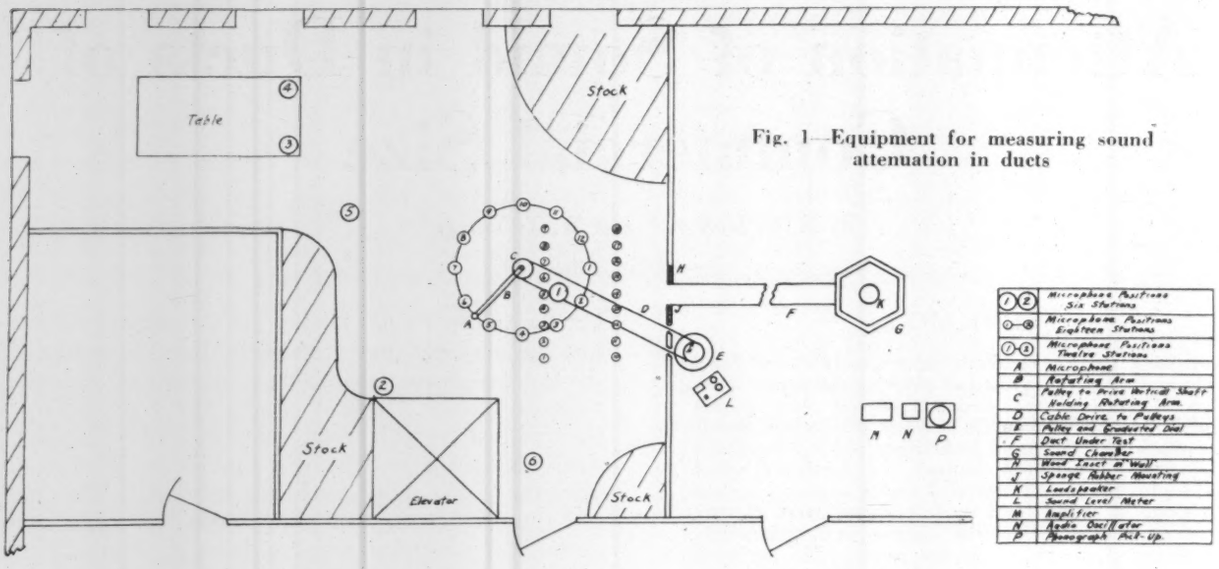

Fig. 1—Equipment for measuring sound attenuation in ducts

generated at the source of the duct length the change in receiving room sound level then indicates the amount of sound attenuated by the length of duct added or removed. The sound source is placed inside of a double shell hexagonal soundproof chamber, which can easily be moved on roller bearing wheels to any position in a long room which may be called the *sound testing room*. Provision is made for the insertion of one end of the duct under test into the sound chamber. The duct extends from the sound chamber to one wall of the testing room. An opening in the wall permits the duct to feed sound into the adjoining room which is referred to as the receiving room.

For the tests made by the authors, non-directional piezo-crystal microphones were used in conjunction with a General Radio Type 759A sound level meter. Several methods of microphone placement in the receiving room were tried for the purpose of finding points that would give a measurement of the average sound level of the receiving room. At first, six points, or stations, were chosen at varying heights and distances from the entrance of the duct into the receiving room. When sound was generated in the sound chamber the microphone in the receiving room was moved to each successive station and the sound level was recorded for each point. An average of the six readings was taken as an average sound level for the room.

In order to assure the greatest possible accuracy, the microphone was always placed for each test in exactly the same position at each station. It was found that the presence of an observer in the room caused a marked change in the room sound pattern, therefore all sound level readings were observed from a position outside the receiving room. In using this system care had to be taken that none of the contents of the receiving room was shifted or removed during any test. The assumption that an average sound level for the room could be obtained by an average of only six readings was checked. By selecting several more series of six stations, each having average distances from the duct entrance to the room about the same as for the original six stations, average sound levels for the room were obtained. The intensity of sound in the sound chamber was held constant and the results of the check tests showed that a six-station average was sufficient as long as no one station was placed near any large object capable of reflecting a large amount of sound directly at the microphone. The average distance of the microphone positions from the duct opening affected the level measured for the room. A series of tests was made using eighteen stations all of which were near the duct opening into the receiving room and it was found that a higher average level for the room was obtained than with the use of the six station method.

One feature of this receiving room level method of testing is that the measurement of sound attenuation in the duct is not dependent upon the absolute average receiving room sound level. As long as an average level for the room is always obtained from the same stations for one series of tests, it makes no difference whether or not the average found coincides with the true average for the room. This is true because the attenuation is calculated, not from the room level, but from the change in room level produced by a given change in length of duct. The effects of entrance losses and disturbances, as well as the difference in true room sound level from the measured room sound level are cancelled out when the attenuation is obtained from the difference in measured room levels for a given change in duct length.

In order to facilitate the accurate placement of the microphone for obtaining the sound level in the receiving room, it was supported at the end of a 4-ft arm which was attached perpendicularly to a rotating vertical shaft in the center of the room. The rotation of the vertical shaft and hence the position of the microphone in the room could be controlled from the testing room by means of a system of pulleys and cables and a calibrated index dial. (Figs. 2, 3.)

Test Results

Tests were performed to determine the relationship of sound attenuation to flue size, shape, and absorbing characteristics, using flues of commercial size. In some of these tests, sounds of single frequency were generated by an audio oscillator having a frequency range of

100 to 10,000 Hz (cycles per second), the output of which was amplified and fed to a conical speaker freely suspended on rubber mountings inside the sound chamber. For some of the tests, a typical fan noise was used as the sound source to duplicate conditions found in actual duct installations. This fan noise was produced as a phonograph recording of the noise from a typical plenum chamber in operation and was fed through the speaker in the plenum chamber. It is also possible to mount a fan and plenum chamber on wheels, thus including in the sound measured that caused by air flow in the system. The work included investigations of round galvanized metal ducts, and round and rectangular pre-fabricated asbestos ducts. Investigations using sounds of various single frequencies indicated that neither metal nor asbestos ducts are in themselves resonant to any frequency in the audible range, and that all substantial resonant effects are functions of the length of the duct only. The middle range of frequencies from 500 to 2000 Hz are absorbed more readily than sounds of lower frequency.

Figs. 4 and 5 show the wide variation of average sound level in the receiving room when the length of the ducts indicated was varied in 3-in. increments. These observations were made using twelve stations in the receiving room. Sound level observations made when the length of the ducts was varied in increments of 3 ft or more were made using six stations in the receiving room. The variation of receiving room sound level caused by this change in duct length is of the order of three decibels, but, as will be noted from the graph, the average attenuation follows closely that of the multi-frequency fan noise of Figs. 6, 7 and 8. The 1000 and 2000 Hz sounds used were amplified to produce a sound level of 110 db in the sound chamber, while the 100, 250 and 500 Hz sounds were amplified to produce a sound level of 100 db. The graphs of Figs. 4 and 5 indicate the difficulty of predicting attenuation in any duct system of average characteristics if any given single frequency predominates, as a room heated by a duct fortuitously of resonant length may have a sound level due to the conditioning equipment ten decibels higher than the level in a room heated by a duct of anti-resonant length. It is to be noted that this effect would not be present in highly absorbing ducts, and due to lack of any predominant sound frequency, is not usually present in practice.

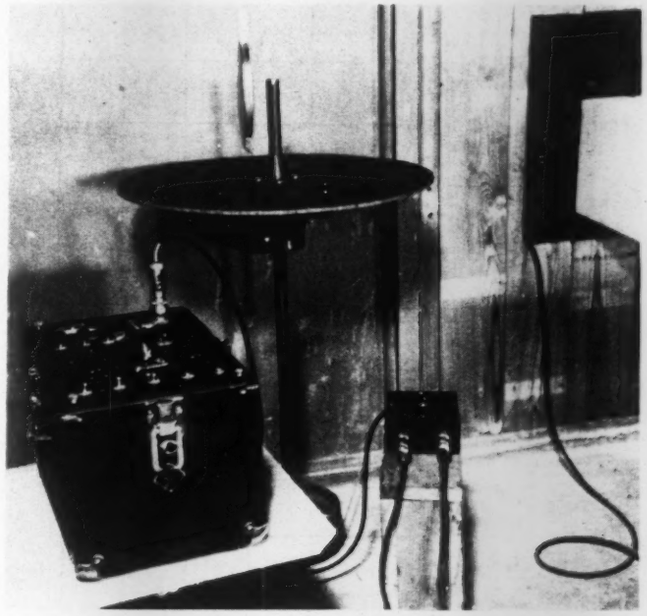

Fig. 3—Control mechanism for the revolving microphone. The mechanism for revolving the microphone is coupled by cable to the graduated dial shown

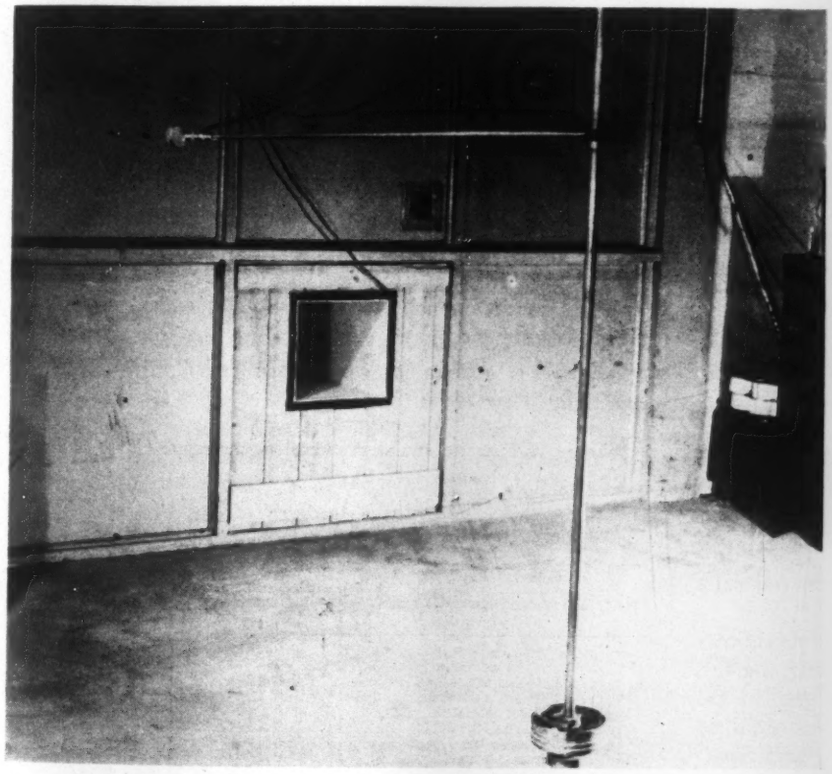

Fig. 2—Receiving room, showing the mechanism for placing the microphone to obtain an average room sound level

Fan noise contains a large number of sound frequencies, and it was noted that sound in the receiving room when such noise was present in the plenum chamber did not change materially with small changes in duct length. For this reason, it is possible to predict quite closely the sound attenuation in any given length of duct in practice.

Using the phonograph reproduction of the fan noise amplified to produce a sound level of 100 db inside of the sound chamber, measurements of the sound level in the receiving room were made for duct lengths ranging from three feet up to 30 ft. Figs. 6, 7 and 8 show the relationships between the average receiving room sound level and duct length for various ducts tested.

As may be seen from the graphs of these figures, the attenuation per unit length is substantially linear for ducts longer than a few feet, in agreement with the predictions of the references cited. The higher attenuations of the first few feet of the ducts are variable with the duct shapes and sizes, as is to

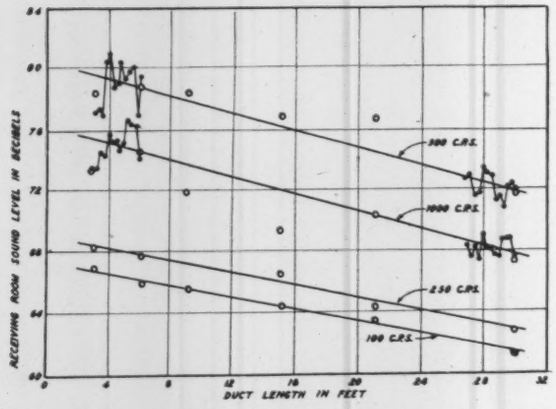

Fig. 4—Sound level in receiving room for various lengths of 11½ in. x 11½ in. asbestos duct with a constant sound intensity of various frequencies at the source

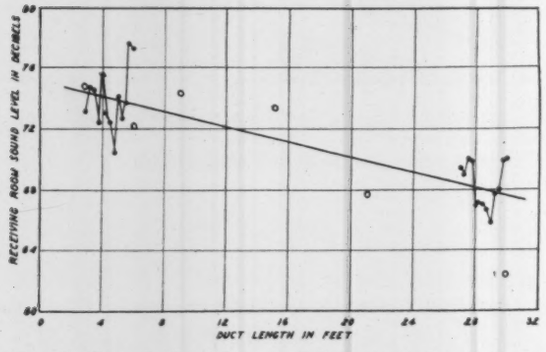

Fig. 5—Sound level in receiving room for various lengths of 11½ in. x 11½ in. asbestos duct with a constant sound intensity of 2000 Hz frequency at the source

be expected, and the increase in attenuation over the attenuation in the same length of duct farther from the source is conveniently added to the attenuation at the duct entrance, as it appears to be substantially constant for a given duct size and shape.

Table 1 shows the sound attenuation in decibels per linear foot and decibels per square foot of duct surface obtained for each size and type of duct. These values are obtained by neglecting the non-linear portion of the curves for very short ducts, and using the linear portions of the curves.

Discussion of Results

Taylor and Sherwin[6] presented two principal formulae; the first,

$$Db = (-10/4f) \log b,$$

where $\frac{1}{4}f$ = the length of duct necessary to present one square foot of inside duct surface to the sound in the duct,

Db = the attenuation per square foot of duct surface in decibels, and

$\log b$ = the attenuation constant (a different value for each frequency of sound),

represents a hyperbolic curve asymptotic to rectangular horizontal and vertical zero axes. By inserting the test values obtained by the authors for Db and $\frac{1}{4}f$ in the above formula, values for the constant $log\ b$ are obtained which vary as much as 100 per cent. Taylor and Sherwin in their tests found variations in the value of the attenuation constant b of almost this same amount. Because of this variation, they used, in the majority of their work, the second relation.

$$(Db - Db_o)f^2 = q,$$

where Db = the attenuation in decibels per square foot,

Db_o = the lower limit of attenuation per square foot,

f^2 = the cross sectional area of the duct in square feet, and

q = the attenuation constant.

Upon applying the data found by the receiving room level method tests to the above formula, the resulting equation, put in a more familiar form, gives for asbestos ducts carrying fan noise:

$$Db = 1/(q'f^2) + Db_o$$

where $q' = 29.8$ (for asbestos duct—a constant),

f^2 = the cross sectional area in square feet, and

$Db_o = 0$.

For standard weight galvanized metal duct the value of Db_0 is zero while the value of the constant q' becomes

$$q' = 96.4$$

Taylor and Sherwin, when working with a highly absorbent duct lining, found that their data gave fairly high values of Db_o. This means that if the cross sectional area of the duct were increased to an infinite value there would still be a measurable attenuation per square foot due to the duct lining. The test results found by the receiving room level method give the term Db_o a value of zero. This appears to be more reasonable, for if a finite value of attenuation per square foot of duct surface did exist at infinite duct size, the attenuation per linear foot in a duct of infinite size would be infinite. The fact must be recognized, however, that the hyperbolic relation of attenuation to cross sectional area of a duct holds true only for a limited range. For very large ducts it is seen that the attentuation of sound intensity would be caused by wall absorption plus the spherical expansion of the sound wave fronts according to the well known square of the distance from the source relationship. A formula to represent the true attenuation of sound for flues ranging in size from small tubes to large tunnels would have to include both the hyperbolic relationship and the spherical wave front relationship. For all average commercial size ducts tested the hyperbolic function appears to give the true attenuation inasmuch as the expansion of the wave does not produce attenuation that is sufficiently large to measure.

Tests made on asbestos ducts with several sounds of single frequencies gave varied values for the attenuation constant q'. By taking Db_o equal to 0 the following relationship was obtained:

$$Db = 1/(KA)$$

where Db = the sound attenuation per square foot of inside duct surface,

Table 1

Type and Size of Duct	Decibels per Linear Foot of Duct	Decibels per Square Foot of Duct Surface
5½ in. x 5½ in. asbestos	0.291	0.159
8½ in. x 8½ in. asbestos	0.181	0.0640
11½ in. x 11½ in. asbestos	0.139	0.0362
2½ in. x 11½ in. asbestos	0.294	0.126
5½ in. x 8½ in. asbestos	0.240	0.103
4 in. x 14½ in. asbestos	0.269	0.0875
8 in. circular asbestos	0.158	0.0754
12 in. circular asbestos	0.140	0.0446
6 in. circular metal duct	0.0708	0.0472
8 in. circular metal duct	0.0625	0.0298
12 in. circular metal duct	0.0438	0.0139

[6]Loc. Cit. Note 3.

K = the attenuation constant (called q' in former equations), and

A = the cross sectional area of the duct in square feet.

For the frequencies used, the values of K were found as follows:

Frequency in c. p. s.	Value of K
100	20.7
250	20.4
500	14.6
1000	13.9
2000	16.9

The attenuation constants for fan noise that were found and applied to the Taylor and Sherwin hyperbolic formula give calculated attenuations per square foot in almost perfect agreement with the values found by the receiving room level method tests. Variations did occur, however, when the ducts varied greatly from a square cross section. In the Table 2 variations were noted for ducts carrying fan noise:

Table 2

Kind of Duct	Duct Dimensions	Aspect Ratio	Percent Variation of Calculated from Actual Attenuation
Asbestos	11½ in. x 11½ in.	1.00	0
Asbestos	8½ in. x 8½ in.	1.00	0
Asbestos	5½ in. x 5½ in.	1.00	0
Asbestos	5½ in. x 8½ in.	1.54	3
Asbestos	4 in. x 14½ in.	3.62	3
Asbestos	2½ in. x 11½ in.	4.60	17
Asbestos	12 in. diameter	—	4
Asbestos	8 in. diameter	—	20
Metal	12 in. diameter	—	16
Metal	8 in. diameter	—	0
Metal	6 in. diameter	—	13

The perfectly square ducts give test values in close agreement with the calculations. Ducts having aspect ratios greater than unity give attenuations slightly greater than the calculated values, while round ducts (aspect ratio for round ducts is some value less than unity) give attenuations less than the calculated values. This variation is to be expected, but the extent of the variation was not known.

The following relation is in reasonably accurate agreement with the test data.

$$Db' = [1/(KA) + b]\ (R)^{0.180},$$

where Db' = the attenuation in decibels per linear foot of duct,

K = the attenuation constant per linear foot,

b = the lower limit of attenuation per linear foot, and

R = the aspect ratio, a dimensionless number.

This relation was devised to take care of the variance in attenuation in ducts having equal cross-sectional areas but having different shapes. The lower limit of attenuation, b, in this formula, has a value greater than 0 because of the fact that it is expressed as decibels per linear foot and not as decibels per square foot. When the cross-sectional area of a duct approaches an infinite value the attenuation caused by one foot of duct length must have a value greater than 0. This would be true because the edges of the sound wave front, when moving along the 1-ft length, would have some sound attenuated regardless of the magnitude of the cross-sectional area. A duct of infinite size would present infinite absorbing area to the edges of a sound wave front.

The value of aspect ratio to be applied to a round duct is not known, but the data indicate that it must be

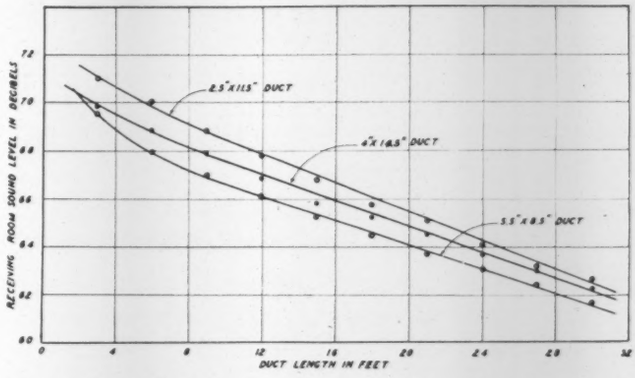

Fig. 6—Sound level in receiving room for various lengths of duct with 100 db sound intensity (fan noise) at the source. Rectangular asbestos ducts of aspect ratio greater than unity

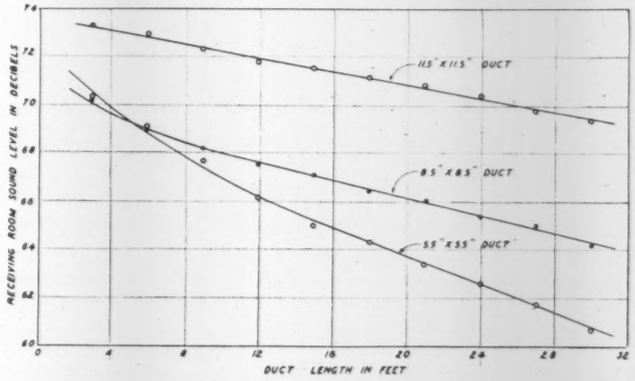

Fig. 7—Sound level in receiving room for various lengths of duct with 100 db sound intensity (fan noise) at the source. Rectangular asbestos ducts having an aspect ratio of unity

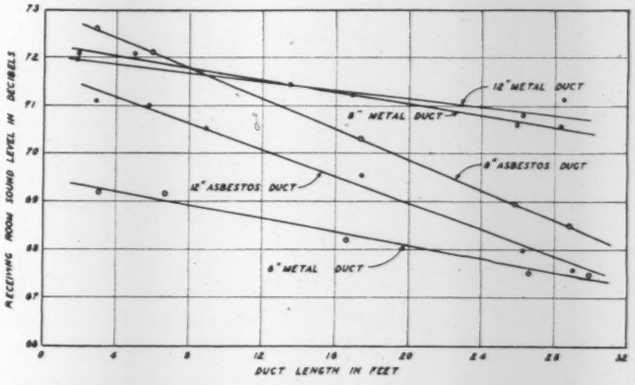

Fig. 8—Sound level in receiving room for various lengths of duct with 100 db sound intensity (fan noise) at the source. Round asbestos and metal ducts

less than unity. In the absence of any proven value of this aspect ratio for a round duct, a value of 0.55 is found experimentally to check reasonably well with the last formula above. For sound work, at least, the value found appears to be of the proper magnitude. Since the sound absorbing perimeter of a round duct is less than the perimeter of a square duct having an equal area and a round duct does not offer any right angle corners in which to trap sound waves it appears to be entirely reasonable that the aspect ratio of a round duct should be on the order of one half to two thirds of that of a square duct.

The formula including aspect ratio gives reasonably

good results for the following values for the constants K and b:

	Value of K	Value of b
Asbestos ducts	23.9	0.1044
Metal ducts	142.5	0.0450

The variations of test values from the calculated values with the use of the constants for ducts carrying fan noise are:

Table 3

Kind of Duct	Duct Dimensions	Aspect Ratio	Percent Variation of Calculated from Actual Attenuation
Asbestos	11½ in. x 11½ in.	1.00	0
Asbestos	8½ in. x 8½ in.	1.00	1
Asbestos	5½ in. x 5½ in.	1.00	0
Asbestos	5½ in. x 8½ in.	1.54	2
Asbestos	4 in. x 14½ in.	3.62	0
Asbestos	2½ in. x 11½ in.	4.60	21
Asbestos	12 in. diameter	0.55	0
Asbestos	8 in. diameter	0.55	20
Metal	12 in. diameter	0.55	0
Metal	8 in. diameter	0.55	7
Metal	6 in. diameter	0.55	0

It is to be noted that the calculated and obtained attenuations for the 2½-in. × 11½-in. rectangular asbestos and 8-in. round asbestos ducts are not in good agreement. While 20 per cent is not a large error in work of this nature, it is felt that the method is not subject to such error, and that the formula rather than the method is in error.

Conclusions

The test results herein presented appear to give a reasonably accurate measure of the attenuation of sound in the types of air ducts tested. The need for further test data on all different sizes and types of duct construction employed in the field of forced air conditioning is recognized. Along with a knowledge of the attenuation of sound in air ducts there is also a need for figures giving the attenuation of sound as it passes through the numerous fittings used in the average air duct installation. The method presented in this paper for experimentally obtaining attenuation data is believed to be sufficiently accurate and at the same time simple in its operation as to provide an acceptable method for obtaining the attenuation measurements needed in modern air duct design.

The authors are greatly indebted to Mr. R. A. MacArthur for his interest and assistance during the course of the research and in the preparation of this paper.

Honorary Member Lester P. Breckenridge Dies at 82

Dr. Lester Paige Breckenridge, professor emeritus of mechanical engineering at Yale University, consulting engineer and inventor, died at his summer home, The Brakens, North Ferrisburg, Vt., on August 22, at the age of 82 years.

He is survived by Mrs. Susan Ford Breckenridge, his second wife, and two daughters, Mrs. Henry Dirks, East Lansing, Mich. and Mrs. David Luckenbill, Redlands, Calif. to whom the Officers and Council express their most sincere sympathy.

Dr. Breckenridge was born May 17, 1858, at Meriden, Conn. He served as apprentice for three years with H. B. Smith Co., Westfield, Mass., and was graduated from the Sheffield Scientific School of Yale University in 1881 with the degree of Ph.B. Later he received the honorary degree of M.A. from Yale in 1909, and the degree of doctor of engineering in 1910 from the University of Illinois. For eight years from 1882-91 he was instructor in mechanical engineering at Lehigh University. He was professor of mechanical engineering at Michigan Agricultural College from 1891-93, and professor of mechanical engineering from 1893-1909 and director of the Engineering Experiment Station from 1905-09 at the University of Illinois. His association as a member of the faculty of Yale began in 1909 when he became professor of mechanical engineering of the Sheffield Scientific School and continued until 1923 when he retired as Professor Emeritus of Mechanical Engineering.

In addition to his educational work Professor Breckenridge was a consulting engineer, particularly in connection with power, heating and ventilating. He has been engineer in charge of the Boiler Division, U. S. Geological Survey, and the fuel testing plant at St. Louis erected in 1904. He contrived and equipped dynamometer cars during 1897-99, and in 1901 he invented an automatic recording machine.

Dr. Breckenridge served as chairman of the Advisory Board of the Super-power Survey from 1920-21 and was a member of the World Power Conference. He held membership in the *American Society of Mechanical Engineers* and was vice-president of the organization from 1907-09, a member of the *Society for the Promotion of Engineering Education* and the *Western Society of Engineers* of which he was vice-president 1905-06. His clubs included the Yale and Engineers Clubs of New York; and the Graduates Club of New Haven.

Professor Breckenridge joined the ASHVE in 1920 and has contributed several papers to its Transactions. He always retained a keen interest in the progress of the heating and ventilating profession and greatly enjoyed the research reports.

Heating, Ventilating and Air Conditioning Courses

A SURVEY of courses offered in heating, ventilating and air conditioning shows that many universities and colleges have added courses of this type to their regular engineering curriculum. The information given here was furnished by the registrars of over 100 universities and colleges offering a degree in engineering and includes essential data for those desiring evening instruction, as well as a full undergraduate program in a comprehensive engineering curriculum.

EAST

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Bucknell University	Lewisburg, Pa.	G. M. Kunkel	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Carnegie Institute of Technology	Pittsburgh, Pa.	C. M. Humphreys T. F. Rockwell	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Plumbing, Laboratory
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Clarkson College of Technology	Potsdam, N. Y.	J. A. Ross, Jr. H. A. Weiss H. H. Davis	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Clemson Agricultural College	Clemson, S. C.	D. H. Shenk J. H. Sams	Day	Heating, Ventilating, Air Conditioning, Refrigeration
College of City of New York	New York, N. Y.	J. R. Weiss	Day and Evening	Heating, Ventilating, Air Conditioning
Columbia University	New York, N. Y.	C. E. Lucke H. L. Parr T. Baumeister, Jr. C. F. Kayan	Day and Evening	Air Conditioning, Laboratory
Cornell University	Ithaca, N. Y.	F. O. Ellenwood C. O. Mackey A. C. Davis W. M. Sawdon	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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Princeton University	Princeton, N. J.	L. F. Rahn	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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South Carolina State A&M College	Orangeburg, S. C.	P. V. Jewell E. M. Adams	Day	Heating, Ventilating
Swarthmore College	Swarthmore, Pa.	G. B. Thom	Day	Heating, Ventilating, Air Conditioning, Refrigeration
Syracuse University	Syracuse, N. Y.	A. R. Acheson H. W. Blackburn J. Carpenter	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Temple University	Philadelphia, Pa.	Mr. Sitzer Mr. Lowell Mr. Buhner	Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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Lehigh University	Bethlehem, Pa.	M. C. Stuart	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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Massachusetts University Extension	Boston, Mass.	R. U. Fittz P. A. L. Foulds	Evening and Correspondence	Heating, Ventilating, Air Conditioning, Refrigeration
New York University	New York, N. Y.	M. C. Giannini P. B. Gordon T. M. Labberton	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
North Carolina State College	State College Station, N. C.	L. L. Vaughan	Day	Heating, Ventilating, Air Conditioning

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University of Pittsburgh	Pittsburgh, Pa.	F. H. Stiening	Day and Evening	Heating, Air Conditioning, Refrigeration, Laboratory
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University of Virginia	Charlottesville, Va.	A. F. Macconochie	Day	Heating, Ventilating, Air Conditioning, Refrigeration
Villanova College	Villanova, Pa.	J. S. Morehouse	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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Virginia Polytechnic Institute	Blacksburg, Va.	J. I. Clower R. M. Johnston J. B. Jones	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Worcester Polytechnic Institute	Worcester, Mass.	R. P. Kole	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
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Chicago Technical College	Chicago, Ill.	J. G. Dunville H. M. Dunlap John Poland Albert Pelletier	Day, Evening and Correspondence	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Detroit Institute of Technology	Detroit, Mich.	C. C. Winn L. L. Henry	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Fenn College	Cleveland, Ohio	Mr. Parmalee Mr. Eaton	Day and Evening	Air Conditioning
Iowa State College	Ames, Iowa	M. P. Cleghorn	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Kansas State College	Manhattan, Kan.	A. J. Mack B. B. Brainard A. O. Flinner	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Lewis Institute	Chicago, Ill.	J. Wolf W. S. Bodinus	Day and Evening	Air Conditioning, Refrigeration, Laboratory
Louisiana University	University, La.	H. Johnson H. W. Waterfall G. F. Matthes	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Michigan College of Mining and Technology	Houghton, Mich.	A. P. Young H. W. Risteen R. R. Seeber T. E. Richards	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Michigan State College	East Lansing, Mich.	L. G. Miller C. H. Pesterfield I. M. Campbell W. E. Reuling	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Mississippi State College	State College, Miss.	A. G. Holmes	Day	Air Conditioning
Northwestern Technological Institute	Evanston, Ill.	B. H. Jennings H. S. Philbrick E. F. Obert R. G. Bigelow	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Ohio State University	Columbus, Ohio	A. I. Brown S. M. Marco E. J. Lindahl	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Oklahoma A&M College	Stillwater, Okla.	E. C. Baker V. L. Maleeu V. W. Young Wayne Buerer	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Rose Polytechnic Institute	Terre Haute, Ind.	Carl Wischmeyer O. L. Stock H. C. Gray	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
South Dakota School of Mines	Rapid City, S. D.	E. R. Stansaas	Day	Heating, Ventilating, Air Conditioning
South Dakota State College	Brookings, S. D.	R. E. Gibbs W. M. Becker	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Southern Methodist University	Dallas, Texas	Noble Sherwood	Day and Evening	Heating, Ventilating, Air Conditioning
Tennessee Polytechnic Institute	Cookeville, Tenn.	D. M. Lee	Day	Heating, Ventilating, Air Conditioning
Texas Technological College	Lubbock, Texas	H. L. Kipp	Day	Heating, Ventilating, Air Conditioning

NAME	ADDRESS	INSTRUCTORS	SESSION	SUBJECTS
Tulane University	New Orleans, La.	A. L. Dunlap A. M. Hill	Day	Air Conditioning, Refrigeration
University of Akron	Akron, Ohio	F. S. Griffin Robert Cure	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Alabama	Tuscaloosa, Ala.	D. H. McCuaig	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Dayton	Dayton, Ohio	A. G. Hofmann A. R. Weber	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Detroit	Detroit, Mich.	F. J. Linsenmeyer L. Lentz	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Iowa	Iowa City, Iowa	H. O. Croft	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Illinois	Urbana, Ill.	W. H. Severns H. J. Macintire	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Kansas	Lawrence, Kansas	Afred Sluss John King Ralph Tait Howard Henry	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Kentucky	Lexington, Ky.	Perry West J. W. May S. B. Walton L. E. Nollau	Day	Heating, Ventilating, Air Conditioning, Laboratory
University of Michigan	Ann Arbor, Mich.	Axel Marin F. N. Calhoon H. E. Keeler	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Missouri	Columbia, Mo.	E. S. Gray J. R. Wharton Milo Bolstad	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Nebraska	Lincoln, Nebr.	A. A. Luebs J. W. Haney	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of North Dakota	Grand Forks, N. D.	A. J. Diakoff D. J. Renwick	Day	Heating, Ventilating, Air Conditioning, Refrigeration
University of Oklahoma	Norman, Okla.	E. F. Dawson	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of South Dakota	Vermillion, S. D.	N. W. Davidson	Day	Heating, Ventilating, Air Conditioning
University of Tennessee	Knoxville, Tenn.	Mack Tucker	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Texas	Austin, Texas	W. R. Woolrich H. E. Degler B. E. Short	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Toledo	Toledo, Ohio	F. L. Fuller	Day and Evening	Heating, Ventilating, Air Conditioning
University of Wisconsin	Madison, Wisc.	G. L. Larson D. W. Nelson L. A. Wilson	Day and Correspondence	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Washington University	St. Louis, Mo.	E. L. Ohle F. A. Berger H. Kuenzel	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Wayne University	Detroit, Mich.	A. L. Hesselschwerdt F. H. Emerson	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
		WEST		
Colorado State College	Fort Collins, Colo.	I. T. Strate J. H. Scofield Joseph Pinksy	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
New Mexico State College	State College, N. M.	J. H. Butler M. T. Lewellen	Day	Heating, Ventilating, Air Conditioning, Refrigeration
Oregon State College	Corvallis, Ore.	M. C. Phillips E. C. Wiley W. H. Martin	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
Stanford University	Palo Alto, Calif.	A. B. Domonoske B. M. Green U. A. Patchett A. L. London	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
State College of Washington	Pullman, Wash.	G. E. Thornton	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Arizona	Tucson, Ariz.	P. M. Thornburg	Day	Air Conditioning
University of California	Berkeley, Calif.	B. F. Raber L. M. K. Boelter F. W. Hutchinson	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Colorado	Boulder, Colo.	W. F. Mallory W. S. Beattie C. A. Wagner N. A. Parker	Day and Evening	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Denver	Denver, Colo.	R. E. Nyswander	Day and Evening	Air Conditioning
University of Idaho	Moscow, Idaho	H. F. Gauss W. Schroeder	Day	Heating, Ventilating, Air Conditioning, Refrigeration
University of Nevada	Reno, Nev.	F. H. Sibley	Day	Heating, Ventilating, Air Conditioning
University of New Mexico	Albuquerque, N. M.	M. E. Farris E. F. Smellie A. D. Ford	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Santa Clara	Santa Clara, Calif.	R. A. Seban	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Utah	Salt Lake City, Utah	R. D. Baker	Day	Heating, Ventilating, Air Conditioning, Refrigeration
University of Washington	Seattle, Wash.	E. O. Eastwood	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory
University of Wyoming	Laramie, Wyo.	R. S. Sink N. H. Sanders	Day	Heating, Ventilating, Air Conditioning, Refrigeration, Laboratory

Sam Houston Monument

Fall Meeting in Houston

October 14-15

A TWO day meeting of the Society will be held at Houston, Texas, October 14 and 15, and this will be featured by a meeting of the Council, the presentation of six papers at the Technical Sessions, an informal banquet and dance, a series of inspection trips, and other entertainment features planned by the Committee on Arrangements of the South Texas Chapter.

According to the announcement of General Chairman C. A. McKinney early arrivals will have an opportunity to see the football game between Rice Institute and Louisiana State University on Saturday evening, October 12, and those who wish to play golf on Sunday morning, October 13, will enjoy the privileges of the Brae Burn Country Club. In the afternoon, a sightseeing trip on Bayshore Drive and a visit to Galveston is on the program.

Registration, directed by D. S. Cooper, will commence Monday morning at 8:30 a.m. on the mezzanine floor of the Rice Hotel. Among the subjects for discussion at the technical sessions are Research Study of Instruments for Determining Air Distribution in Rooms, the Agents for Chemical Dehumidification, New Investigations in the Lighting Field Relating to Air Conditioning Load Factors, and the Application of Evaporative Cooling in the Southwest.

At noon on Monday a get-together luncheon will be held and a speaker of national reputation will discuss industrial problems of general interest. In the evening an informal banquet and dance will be held in the ballroom of the Rice Hotel. Arrangements for this event will be in the hands of A. M. Chase, Jr.

Following the technical session on Tuesday morning, a series of inspection trips have been planned and the various tours will be in charge of I. A. Naman.

A program of special events for the ladies has been planned by A. F. Barnes and the entertainment and sports programs will be directed by A. B. Banowsky and G. D. Maves.

Members of the Houston Chapter extend a cordial invitation to come to Texas for the Society's Fall Meeting and they plan to extend the traditional warm welcome of the Southwest.

Houston is readily accessible because it is connected with principal cities by good roads. Convenient train service with through cars from many cities is available and direct airline schedules are available from the east, north and west. The headquarters, Rice Hotel, is centrally located in the downtown business district of the city and offers rates for air conditioned rooms as follows: Single room with bath—$2.50, $3.00 and $3.50; double room with bath (two persons)—$4.00, $5.00, $6.00 and $7.00.

Houston is a city of nearly 500,000 people and its growth has been phenomenal during the past two decades. When Houston was founded in 1836 its area was two-tenths of a square mile and

A. F. Barnes

A. J. Rummel

A. M. Chase, Jr.

A. B. Banowsky

I. A. Naman

now it covers over 100 square miles and is the largest municipality in the State of Texas.

Houston is an important water and rail shipping point and among the most important commodities are oil, cotton and livestock. For many years Houston has been termed the "oil capital of the world." It has 185 producing fields within 150 miles. The output now averages over 300,000 barrels of oil per day. Although 50 miles from the gulf, ships from all parts of the world dock at Houston. The port ranks third in the amount of total tonnage handled. Cotton also provides a big volume of business for Houston, as nearly a quarter of the world's cotton is grown in Texas, and it is estimated that one-half of the people in the state make their livelihood in some form from the cotton business.

There is much to do and see in Houston—ASHVE Members should make plans now to attend the Fall Meeting October 14 and 15.

Rice Institute

PROGRAM of FALL MEETING

American Society of Heating and Ventilating Engineers
Rice Hotel, Houston, Texas October 14-15, 1940

October 12

1:00 p. m. Reception of Members by Houston Chapter Committee

8:15 p. m. Football Game, Rice Stadium (Rice vs. L.S.U.—Tickets $2.50 per person)

October 13

10:00 a. m. Golf—Brae Burn Country Club (Greens Fee $2.00 per person)

2:00 p. m. Bayshore Drive and Visit to Galveston

October 14

8:30 a. m. Registration (Mezzanine Floor)

10:00 a. m. Technical Session—

Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl.

Cooler Footcandles for Air Conditioning by W. G. Darley

Chemical Dehumidification Agents, by F. R. Bichowsky

12:15 p. m. Get-together Luncheon—($1.00 per person)

1:45 p. m. Sightseeing Trip (register in advance, tickets $1.00)—City trip to Rice Institute, Battle Ground, Sylvan Beach.

1:45 p. m. Informal Golf Matches

2:00 p. m. Council Meeting

4:30 p. m. Friendship Hour for Members and Ladies

7:00 p. m. Informal Banquet and Dance (tickets $2.50 per person)

October 15

9:00 a. m. Registration

10:00 a. m. Technical Session—

Research for the Future, by F. C. Houghten

Direct Evaporative Cooling for Homes in the Southwest, by A. J. Rummel

10:45 a. m. Ladies Breakfast Bridge and Style Show

12:00 p. m. Junior Chamber of Commerce Luncheon—Speaker Stanley Foran. Subject: Americanism—Let's Resell It to the World

2:00 p. m. Inspection Trips

G. D. Maves

W. R. Etie

Cincinnati Chapter Elects Officers

At the annual meeting of the Cincinnati Chapter, held at Twin Oaks Country Club, Latonia, Ky., May 22, 30 members and guests were present when Pres. H. E. Sproull called the meeting to order. Reports of the officers and committees were given. A net loss of seven members was reported.

The business meeting included a discussion of suggestions on methods of selecting Society officers and Council members and endorsement of a resolution to recommend revision of the City Code on Heating, Ventilating and Air Conditioning.

The officers to serve for the 1940-41 term are:

President—R. E. Kramig, Jr.
Vice-Pres.—W. H. Junker.
Secy-Treas.—C. E. Hust.
Board of Governors—H. E. Pillen and H. E. Sproull.

47th Annual Meeting

J. M. Arthur, Jr.
General Chairman

Kansas City will be the scene of the Society's 47th Annual Meeting and the dates selected by the Council are January 27 to 29, 1941. Members of the Kansas City Chapter will act as hosts and the General Committee on Arrangements has been appointed and has held several meetings. General Chairman J. M. Arthur, Jr. has announced that the Committee selected the Muehlebach Hotel for meeting headquarters.

The Kansas City members invite their fellow members to the "Heart of America" to enjoy the 47th Annual Meeting, which will be in charge of the following General Committee on Arrangements: J. M. Arthur, Jr., *General Chairman;* Wm. L. Cassell, *Co-Chairman;* A. D. Marston, *Vice Chairman;* Henry Nottberg, Jr., N. W. Downes, L. A. Stephenson, Edward M. Jolley, F. F. Dodds, M. A. Disney, Mrs. Wm. A. Russell, Henry Gould, F. A. Sheppard, J. E. Matthews and D. M. Allen.

Pacific Coast Meeting and Exposition at San Francisco

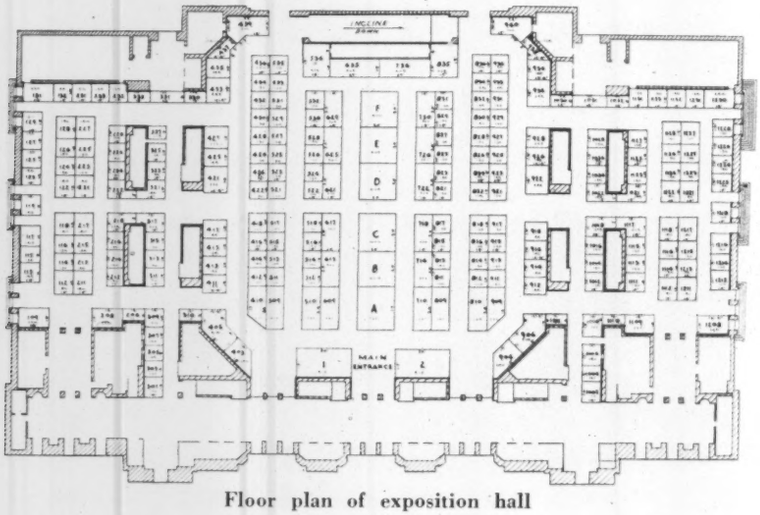
The Council has selected San Francisco for the Semi-Annual Meeting 1941, and during the week of June 16, the Pacific Heating and Air Conditioning Exposition will be held as well as the *Heating, Piping and Air Conditioning Contractors National Association's* Annual Meeting. Members of the Society's Golden Gate Chapter will be hosts to their fellow members who will attend this meeting.

President Giesecke announces the appointment of a Special Exposition Advisory Committee with the following members: W. L. Fleisher, New York, *Chairman;* Prof. E. O. Eastwood, Seattle; H. H. Douglas, Los Angeles; J. H. Gumz, San Francisco; M. J. Hauan, Seattle; Daniel Hayes, San Francisco; J. E. McNevin, Denver; N. H. Peterson, San Francisco; T. E. Taylor, Portland; and Dr. B. M. Woods, Berkeley.

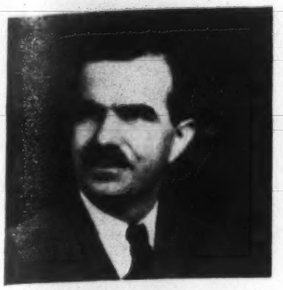
Announcement of the exposition to manufacturers has brought an immediate response and many space reservations have been received from makers of heating, ventilating, air conditioning and accessory equipment. The exposition will be directed by Charles F. Roth, president of the International Exposition Co., and E. K. Stevens will act as associate manager.

This exposition is a special interim show undertaken at the request of the professional and industrial organizations on the Pacific Coast and will not disturb the sequence of the biennial International Heating and Ventilating Expositions at Cleveland in 1940 and in Philadelphia in 1942.

For the first time in its history the ASHVE will hold a Pacific Coast meeting and this gathering will offer an opportunity for all members of the western states to meet at a readily accessible point. It will also afford the opportunity for other members who want to visit the Pacific Coast to meet with their fellow members and thereby combine business with pleasure.



Floor plan of exposition hall



C. M. Ashley

M. K. Fahnestock

H. King McCain

F. C. McIntosh

T. H. Urdahl

Research Candidates

In accordance with the requirements of the Society's Constitution and By-Laws, the Council has selected the names of five members to serve for a three-year term on the Committee on Research commencing 1941, as follows: C. M. Ashley, Syracuse, N. Y.; M. K. Fahnestock, Urbana, Ill.; H. King McCain, Atlanta, Ga.; F. C. McIntosh, Pittsburgh, Pa., and T. H. Urdahl, Washington, D. C.

The names of these candidates will appear on the official ballot to be mailed to members in advance of the 47th Annual Meeting.

New ASRE Data Book

The *American Society of Refrigerating Engineers* announced the publication on September 1 of a new edition of the *Refrigerating Data Book* called Volume 2 (applications edition) which contains a collection of practical information on refrigeration, processes and applications. Special emphasis is placed upon the subject of refrigeration of foods and industrial processes such as oil refining, fuel gas, air reduction etc. This volume contains 60 chapters of 560 pages divided into seven sections and also contains condensed catalog advertising of leading manufacturers

Installation and Use of Attic Fans

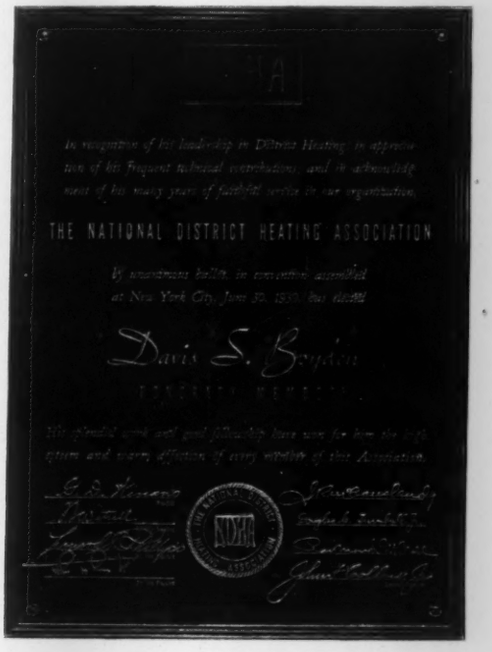
Bulletin No. 52 from the School of Engineering, Texas Engineering Experiment Station, College Station, Texas, covers the subject of the Installation and Use of Attic Fans by W. H. Badgett. This booklet of 48 pages is divided into seven sections and covers the practical application of attic ventilation, fan installation and operating costs, methods of fan selection and details of installation.

Boeddener Succeeds Williams

Announcement has been made by Pres. C. A. Olsen, *National Warm Air Heating and Air Conditioning Association*, that George Boeddener has been appointed Managing Director and Treasurer of the Association to succeed Allen W. Williams, who retired recently after serving the Association for more than 25 years. Mr. Boeddener joined the staff of the Association on February 1, 1940, and has travelled extensively in the interest of the organization. He has been connected with the heating industry for a number of years as general manager of sales for Fox Furnace Co.; sales manager of the heating department of the Norge Division of Borg-Warner Corp., and for a short time he was engaged in the stove manufacturing business.

D. S. Boyden Honored by NDHA

At the Annual Meeting of the National District Heating Association, at French Lick, Ind., D. S. Boyden, of Shirley, Mass., was elected an Honorary Member and received a handsome plaque, which is reproduced.



Colonel Boyden served as President of the *NDHA* and has been active in its affairs for many years. The Colonel's many friends will be delighted to know of the honor conferred upon him.

Dr. Sayers New Head of U. S. Bureau of Mines

Dr. R. R. Sayers, formerly senior surgeon of the U. S. Public Health Service, has been named Director of the U. S. Bureau of Mines at Washington, D. C. He had an active part in the early research investigations sponsored by the ASHVE which established the Comfort Zone and is now serving on Technical Advisory Committees on Physiological Reactions and Air Conditioning in Industry.

Dr. Sayers has been interested in standardization work and is chairman of the *ASA* Committee on Standard Allowable Concentrations of Toxic Dusts and Gases. He is vice-chairman of the Sub-committee on Pneumoconiosis of the Correspondence Committee on Industrial Hygiene, International Labour Office.

He has been active in the work of the *American Standards Association* for some years, as a member of the Safety Code Correlating Committee, and the Building Code Correlating Committee, and of several technical committees.

L. B. Lent Appointed Secretary of American Engineering Council

By action of the executive committee, Colonel L. B. Lent, well known as an engineer, inventor, and trade association executive, has been appointed executive secretary of the *American Engineering Council* and assumed his new duties August 1. He succeeds Frederick M. Feiker, who resigned to become dean of engineering at George Washington University.

Colonel Lent is a native of Brewster, N. Y., and a graduate of Stevens Institute of Technology. After five years as associate editor of the technical magazine *Power* his studies of gas engine development led to an association with the Riverside Engine Co., Oil City, Pa.

During the World War he was assigned to the development of airplane engines at the Curtiss plant in Buffalo, N. Y., subsequently being transferred to Langley Field, Va., as engineer officer and later to Camp Vail, N. J., as commanding officer of Air Service troops at that field. He subsequently had command at Brindley Field and Roosevelt Field.

After the war he became superintendent of the U. S. Air Mail Service and played a prominent part in the development of the early routes connecting Chicago with St. Louis, Minneapolis and San Francisco, and organized the first transcontinental service from New York to San Francisco.

Colonel Lent entered trade association work as chief engineer of the *Common Brick Manufacturers' Association of America*. He later became executive officer of the *Scientific Apparatus Makers Association* and more recently, Colonel Lent has been a consultant in the aviation field.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 7 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by Sept. 16, 1940, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES

AKERS, ARTHUR W., Director, Technicians Institute, New York, N. Y.

BALL, FREDERICK T., Mgr., Stoker, Refrigeration Depts., The Canadian Fairbanks Morse Co., Ltd., Winnipeg, Canada.

BATTAN, STUART W., Mgr., Stuart W. Battan Heating Co., Avondale, Pa.

CONNORS, EDWARD C., Engineer Custodian, Chicago Board of Education, Chicago, Ill.

HOLLAND, WILLIAM T., Engineer, Heating, Piping & Air Conditioning Contractors Milw. Assn., Milwaukee, Wisconsin.

RICHARDS, LESLIE V., Owner, Richards Oil Burner Sales & Service, Malden, Mass.

STEWART, ROBERT SMITH, 7 North Main St., Middletown, Ohio.

REFERENCES

Proposers	*Seconders*
M. M. Kabili (*Non-Member*)	G. A. Belsky
J. F. Kern, Jr.	S. Lee
I. McDonald	P. L. Charles
R. L. Kent	J. B. Steele
E. Nesmith	G. F. Zellhoefer (*Non-Member*)
H. B. Lawton (*Non-Member*)	L. N. Hunter
J. Howatt	L. F. Supple
V. L. Sherman	F. A. Rogers (*Non-Member*)
J. H. Volk	A. S. Krenz
J. S. Jung	C. H. Randolph
Grenville B. Gerrish	Harold M. Tarr
Raymond M. Nee	P. J. Bracken (*Non-Member*)
W. H. Junker	Tom Byrd
R. E. Kramig, Jr.	Carl E. Hust

CANDIDATES ELECTED

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

FARRINGTON, S. EDWARD, Engineer, Moody & Hutchison, Philadelphia, Pa.

METZGER, ALBERT FRANK, Supervisor of Steam Utilization, Allegheny County Steam Heating Co., Pittsburgh, Pa.

ASSOCIATES

KEELING, FRED V., Asst. to Maintenance Supt., Philadelphia Navy Yard, Philadelphia, Pa.

LIGE, WALTER WARREN, Resident Manager, Bell & Gossett Co., Chicago, Ill.

MAST, CLYDE M., Mgr., Heating Dept., H. E. Saviers & Son, Inc., Reno, Nevada.

ROGERS, CHARLES SEYMOUR, Htg. Engr., L. P. Steuart & Bro., Inc., Washington, D. C.

WEBBER, CHARLES H., Sales Engr., Pacific Scientific Co., Los Angeles, Calif.

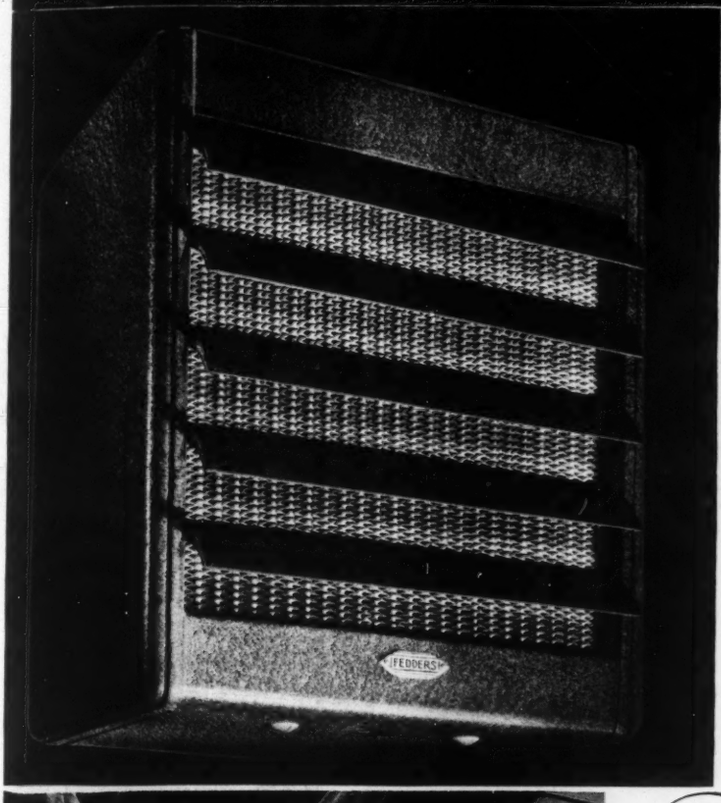
JUNIORS

SACHS, SAM, Research Asst. in Mechanical Engineering, University of Illinois, Urbana, Ill.

SALZER, ALFRED ROGER, JR., Engineer, F. H. Chisholm, M.E., New Orleans, La.

FEDDERS

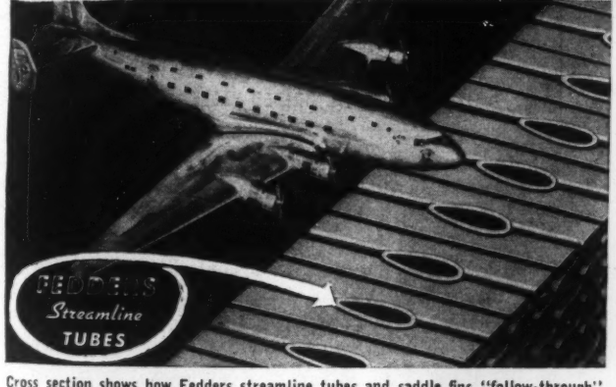
UNIT HEATERS



High heating efficiency, direct control of heat, quiet operation, easy installation and low maintenance cost are a few advantages of Fedders Unit Heater design.

CHECK THESE EXCLUSIVE FEDDERS FEATURES

- ✓ STREAMLINE TUBES combine maximum heat transfer with efficient air handling.
- ✓ NON-CLOGGING FINS designed to reduce dirt accumulation.
- ✓ FULL FLOATING MOUNTINGS eliminate destruction by thermal stresses.
- ✓ DOUBLE HEADERS produce more uniform distribution of steam.
- ✓ INDIVIDUAL TUBES AND FINS designed to "give" laterally to relieve varying stresses between tubes.
- ✓ DEEP, MONO-PIECE CABINET encloses fan and motor as well as eliminates rattles.
- ✓ QUIET OPERATION is the result of sound deadening material, rigid cabinets, rubber mountings and correct design.
- ✓ See the many other features shown in Bulletin 573. Write for your copy today.



Cross section shows how Fedders streamline tubes and saddle fins "follow-through" with identical aero-dynamic principles of modern aviation.

Heat Transfer Specialists Since 1896

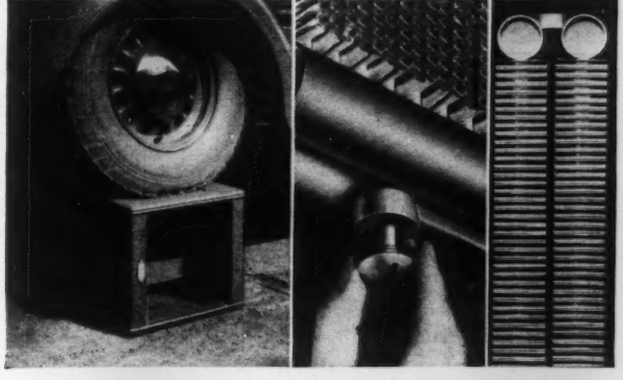
FEDDERS MANUFACTURING CO., INC.
AIR CONDITIONING DIVISION
81 Tonawanda St.,
BUFFALO, N. Y.
Representatives in All Principal Cities

FEDDERS TYPE K HEATING COILS
Built in a complete range of sizes.

FEDDERS UNIT AIR CONDITIONERS
Seven Base Models from 1½ to 25 Tons Capacity.

FEDDERS COOLING COILS
New Complete Range of Sizes for Refrigerants and Cold Water.

ALSO OTHER ASSOCIATED PRODUCTS



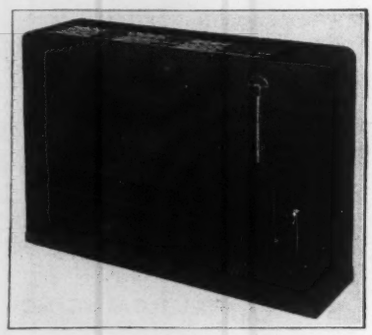
1. Sturdy Fedders Cabinet supports weight of heavy eight cylinder automobile. 2. Fedders patented Full-Floating Mounting eliminates expansion and contraction stresses between heating element and cabinet. 3. Exclusive Double Headers manifolded at center provide unusual free steam passages resulting in longer life.

Equipment
DEVELOPMENTS

For your convenience in obtaining more information about any of this equipment, see coupon on page 144. Add the new products and companies listed here to your Directory Section which you received in your January, 1940, HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed

De Luxe Heater

No. 1920—The new de luxe "hiJet" heater is offered by the manufacturer to provide a quiet and efficient method of heating stores, offices, churches, corridors, markets, etc.; it is available for use with steam or hot water. Air is drawn through the recirculating grille into the unit, through the heating element and filter, and is then discharged into the room through the discharge grille.

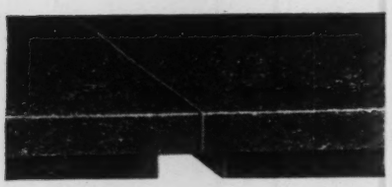


The unit may be mounted on the floor, placed on the wall or suspended from the ceiling and is arranged to discharge upward, downward, or horizontally. It is furnished in six sizes with capacities from 24,800 Btu and 250 cfm to 145,200 Btu and 1685 cfm. A speed controller mounted inside the cabinet allows selection of the low, medium or high speed.

Features include "Stay Tube" construction to maintain proper relationship between headers without increasing the strain on the bends, and to allow any entrained moisture to drain directly from the supply header to the return header without entering any of the other tubes of the heating element, the maker states. The cabinet is of heavy furniture steel, is constructed with rounded corners, and is finished in brown baked enamel with trim of polished stainless steel.—Herman Nelson Corp., 2nd St., Moline, Ill.

Roof Insulation

No. 1921—A new type of roof insulation designed to withstand moisture conditions which reduce or destroy the effectiveness of insulation has been put on the market and is called "Vapor-seal." A special feature of the product are channels designed to eliminate roof blisters and buckling caused by air expansion within the roof insulation. The channels serve as expansion chambers which relieve air pressure against the roof covering; they also relieve accumulations of vapor pressure built up by high humidities and temperatures such as are present in textile mills, laundries, bakeries, food storage buildings and printing, photographic and tobacco establishments, the maker states.

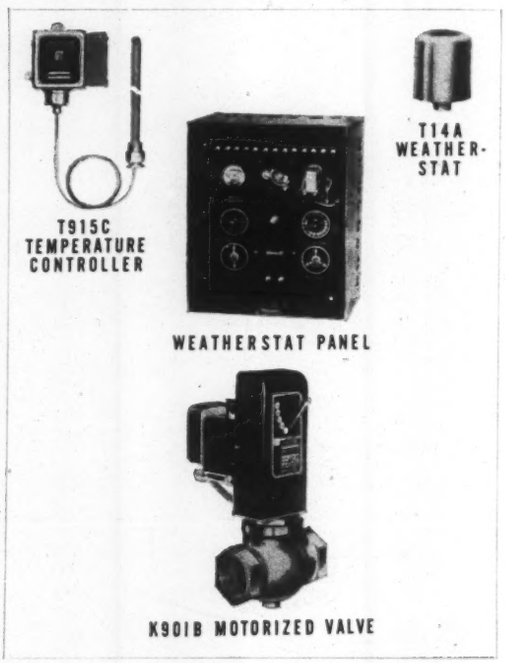


The channels are obtained by fabricating the insulation units with offset edges on the lower sections, so that when the tops of two edges are butted together a channel is formed along the under side of the joint.

The coefficient of conductivity of 0.30 Btu per sq ft per hr per F is reported. The product is available in thicknesses of 1, 1½, 2 and 3 in.—Celotex Corp., 919 N. Michigan Ave., Chicago, Ill.

Modulating Zone Control System

No. 1922—A new modulating zone control system employs the T14A "Weatherstat" as its master controller. This temperature controller is mounted outside the building on the outer wall of the zone it is to control and functions like a miniature building in that it has its own thermostat and heating plant, the latter in the form of an electric heating coil. Consequently, it can be adjusted to reflect heat losses in relation to outside conditions to the same degree as the zone it is controlling, according to the manufacturer. This enables the instrument to govern heat input to the building as determined by heat losses due to outside temperature, wind direction, wind velocity and solar radiation.



One of the features of this zone control system is that it provides for the continuous flow of steam during lower outdoor temperatures and for two position operation of the modulating motorized valve during higher outdoor temperatures. The fact that the zone valve is operated in a two position manner during outdoor temperatures that require very little steam to heat the building eliminates distribution difficulties, it is stated. The continuous flow of steam during lower outdoor temperatures prevents expansion noises in the piping, and eliminates cold radiators with resultant stratification of air, it is said.

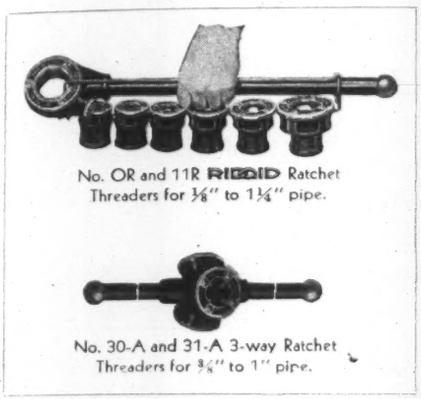
This system is designed to control single or multiple zone jobs

with each zone having a separate control panel. The system is applicable to two pipe steam heating systems only, and cannot be applied to one pipe systems. This system is recommended by the maker for installations where a constant source of steam is available and where a motorized steam valve can be installed. Due to the fact that the amount of steam supplied to the system is varied, it is necessary that all radiators be properly orificed, and that a relatively constant pressure differential be maintained between the supply side of the motorized valve and the system return.—Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave., South, Minneapolis, Minn.

New Pipe Tools

No. 1923—Latest additions to the "Ridgid" line of pipe tools are five new ratchet and three-way threaders for small pipe.

Nos. OOR, OR, and 11R are of new, stronger design in all-steel malleable alloy to thread ⅛ to 1¼ in. pipe. Separate sets of semi-highspeed tool steel chaser dies are accurately cut, easily removed for regrinding, the maker states. In No. OOR, die heads are quickly locked in or removed by a pull of the ratchet knob. In Nos. OR and 11R die heads push out for changing, snap into ratchet ring from either side.



No. OR and 11R RIDGID Ratchet Threaders for ⅜" to 1¼" pipe.

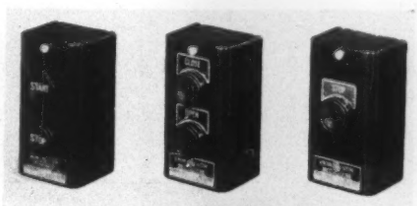
No. 30-A and 31-A 3-way Ratchet Threaders for ¾" to 1" pipe.

No special dies are needed for threading pipe close to wall; it is only necessary to turn dies upside down and shift to positions marked on die heads.

The Nos. 30A and 31A three-way threaders for small pipe have virtually the same features as the series described above. They are compact, have double ball end handles and thread pipe from ⅜ to 1 in.—Ridge Tool Co., Box 670, Elyria, Ohio.

Push Button Stations

No. 1924—New one and two button, standard duty push button stations, offer improvements in operation, appearance and ease of installation, according to the maker. They are similar in appearance to the "G-E" heavy duty stations, and their ⅞ in. molded buttons are made slightly concave for convenience.



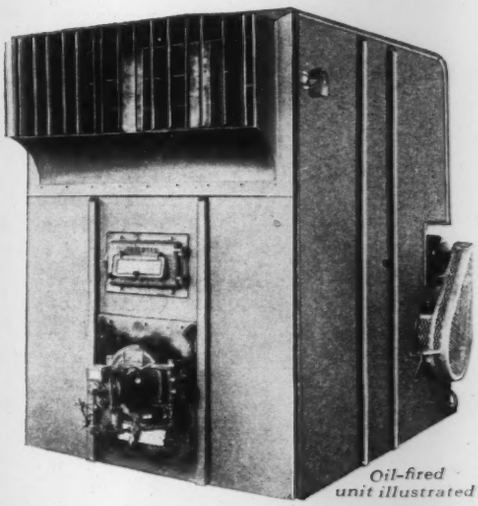
They are protected from accidental operation by guard rings. The words "Start" and "Stop" molded into the front of the buttons are filled with white paint to make them easily readable, and other identification can be provided on separate plates attached to the enclosure directly above the buttons. —General Electric Co., 1 River Rd., Schenectady, N. Y.

Boilerfeed Pump

No. 1925—The makers of the "pressure equalizing" boilerfeed pump have announced that three sizes are now available with pressure tanks that conform to ASME specifications. These tanks were developed to provide a wide margin of safety for high pressure installations and have made possible a new size of the pump—one that is suitable for use with boilers up to 250

• You Can Amortize The Cost of This Warm Air Heating Plant in a Minimum of Time

The Directherm, Direct-Fired Warm Air Unit Heater For Plants of All Types



Oil-fired unit illustrated

300,000 to 1,500,000 BTU CAPACITY

- **DIRECTHERM WARM AIR HEATERS FOR OIL, GAS OR COAL** are available in six standard sizes with capacity from 300,000 to 1,500,000 Btu's. They are made of heavy gauge steel plate, with major sections all welded and flue gas headers are readily cleanable.
- **VENTILATION AND AIR RE-CIRCULATION.** The Directherm can be easily hooked up for outside air intake. Air filters may be used in the intake box when desired.
- **INSTALLATION.** These units, when assembled, require nothing more than a stack and an electrical connection (plus a gas or oil fuel hook-up) and can be made fully automatic in operation when using oil, gas or stoker.
- **PORTABILITY.** Directherm Heaters may be readily removed from one location to another or from one plant to another when building expansion programs demand such alterations in the heating system.
- **LOW INSTALLATION AND OPERATING COSTS.** Because of their low first cost, the investment in Directherm Warm Air Heaters can be amortized in a minimum of time and are thus particularly desirable for plants of possible semi-permanent utility. High efficiency of combustion with discharge of heat direct from the unit makes for low heating cost.

LEADING ARCHITECTS AND ENGINEERS

Endorse Warm Air Heating For Plants. The Directherm Warm Air Unit is ideal for industrial heating and will meet the requirements demanded of the new tendency to designate warm air installations for plant heating.

- **DUCT WORK.** While the Directherm Heater will provide thorough heat distribution without duct work, where necessity requires it may be hooked up with a system for further heat distribution. The fan equipment is of ample capacity to overcome duct resistances.

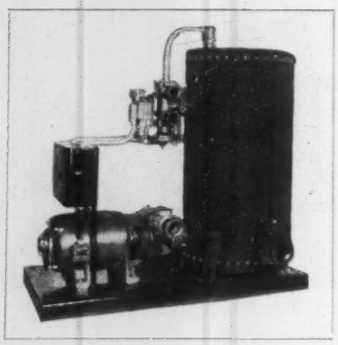
Factory Representatives. A few territories still open. Write for details.

ORDER NOW FOR PROMPT DELIVERY

AIRTHERM MANUFACTURING COMPANY

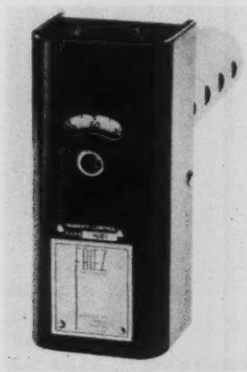
712 S. SPRING AVE. • • ST. LOUIS, MO.

hp. All three sizes are suitable for pressure up to 125 lb and are rated to serve boilers of 100, 150 and 250 hp, the maker states. A second model of the new size is fitted with an ASME tank that will withstand up to 150 lb pressure.



The pressure tank is the heart of the pump's "equalizing" action. When the pump is ready to operate boiler pressure is admitted into this pressure tank, thus balancing the pressure that faces the pump discharge. Consequently only a small slow speed pump is required, according to the manufacturer.—Johnson Corp., 830 Wood St., Three Rivers, Mich.

Industrial Insertion Humidistat



No. 1926—A new insertion humidity control is suitable for use where dust, dirt and other adverse service conditions would prevent satisfactory operation of other types, the maker states. It features the multiple human hair element, and a switch mechanism fully enclosed in a molded plastic case. Control of both humidifying and dehumidifying are provided over a range of from 10 to 100 per cent relative humidity, with a sensitivity of plus or minus 1 per cent.

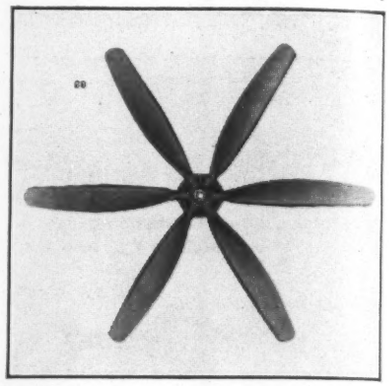
This new instrument is offered for use in bakers' proof boxes, incubators, low temperature ovens, test cabinets and similar applications.—Julien P. Friez & Sons, 4 N. Central Ave., Baltimore, Md.

Adjustable Pitch Cooling Tower Fan

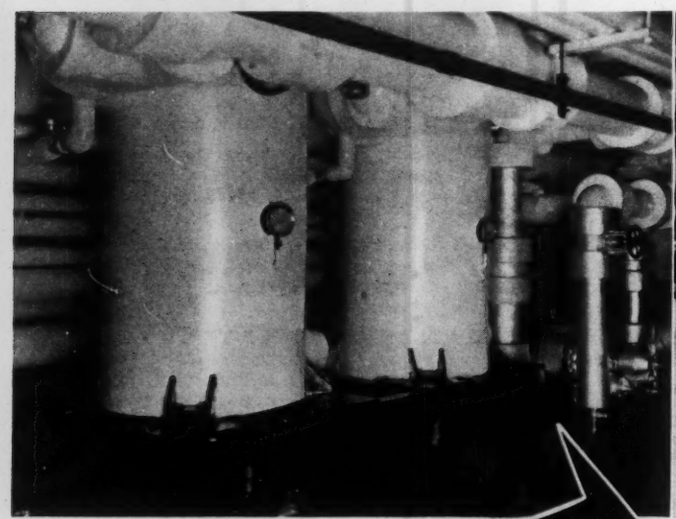
No. 1927—A specially designed modification of the patented "Tear-Drop" fan blade has been developed for cooling tower use. It permits high speed air movement at tip speeds well below the requirement for quiet operation in any location, according to the manufacturer.

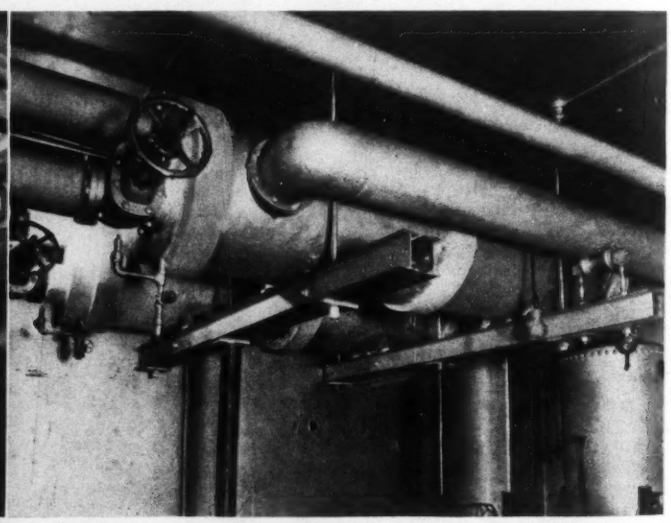
These adjustable pitch fans are made regularly in sizes ranging from 36 to 130 in. diameter and built to special order in other sizes.

It has also been announced that the same manufacturer's line of "Charavay" industrial fans has been extended and many new features included. Basic designs in the line include the "Tear-Drop," standard and "Birdwing" propellers. Each is designed to meet a definite industrial or commercial need.



These fans are now available in single propeller, two propeller and multi-blade types. New mounting styles include an improved extension shaft, a new belt drive blower, belt drive exhaust fan and a slow tip speed fan.—Hartzell Propeller Fan Co., P. O. Box 909, Roosevelt Ave., Piqua, Ohio.



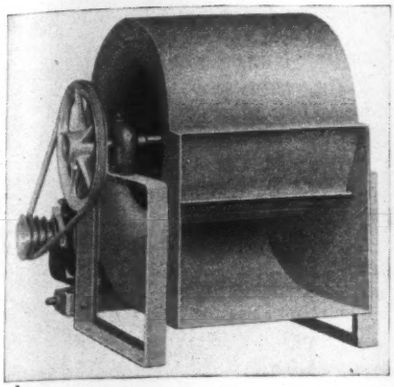


CONVERTORS
for hot water heating systems

Definite advantages of hot water heating have led to its use in many prominent buildings. Likewise, definite design and construction advantages of Whitlock Convertors have led to their installation for heating and reheating the water used in such systems.
Bulletin 20 illustrates forced and gravity circulation installations and standard size Convertors available. For a copy of this Bulletin — or for engineering recommendations covering any Whitlock Heat Transfer Equipment—write—

WHITLOCK

The Whitlock Manufacturing Co.
44 South St., Elmwood, Hartford, Conn.
District offices in New York, Boston, Chicago, Philadelphia, Detroit, Richmond



We sell Blowers, too!

In fact, building and selling REX Blowers is supposed to be the main part of our business. But sometimes we feel that manufacturing is but secondary, as the following true incident will reveal.

Last November, a furnace manufacturer* asked for a quotation on a REX Blower to be used on a new forced air furnace they were designing. Our field man promptly called and figured out with their engineers the characteristics this blower should have. On the basis of his recommendation they ordered a sample blower for test.

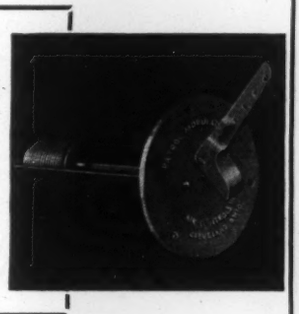
It was not until February that they finished their experimental work and suggested some small changes in the original design. These were made and after further trials, they asked for prices in April. When these were received, they finally ordered their first lot of REX Blowers.

Thus, for six months this manufacturer utilized the specialized training and knowledge of the Air Controls' engineering department as their blower design department without cost or obligation. Our well distributed force of field representatives is ready to cooperate likewise in helping you to solve your forced air problems and assures you of prompt, personal service.

*Name furnished upon request.

PATROL MODULATOR

—is a superior control system for forced, warm air heating units. This sensitive bellows type control regulates the amounts of air delivered and power consumed in direct proportion to bonnet temperatures at a cost considerably less than that of a conventional two-speed control and motor.



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Div. of
The Cleveland Heater Co.
1934 W. 114th St. Cleveland, Ohio

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DRY DEVELOPMENT
MEANS TO YOU
EXPOSURE · WATER BATH · POTASH BATH · WATER BATH · DRYING · TRIMMING
WET DEVELOPED NEGATIVE BLUE PRINTS
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OZALID WHITEPRINTS are developed dry. There is no washing or fixing . . no waste of solutions or preparation of chemical baths. There is no drying of prints. Ozalid prints do not curl or wrinkle and are true-to-scale.

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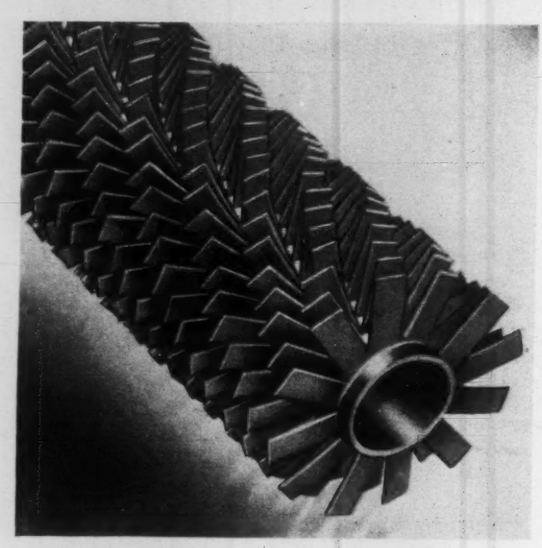


TILCO-FIN

● ● ● THE EXTENDED SURFACE TUBING WITH DUAL EFFICIENCY, HIGH HEAT TRANSFER AND REMARKABLY LOW RESISTANCE ARE CHARACTERISTIC OF ALL SIZES AND TYPES OF TILCO-FIN TUBING.

TILCO-FIN is a patented extended surface tube, the design of which creates an extended surface with remarkably high efficiency. Tests by recognized authorities show a "U" factor far higher than the usual standards and analyses by competent engineers give a developed fin efficiency explained only by the design of the finned surface. TILCO-FIN is designed to give a high heat transfer without creating excessive resistance to the passage of air across its surface. The resistance is actually much less than accepted standards. TILCO-FIN tubes are made in a variety of sizes with many combinations of secondary to prime surface. All have in common the superior performance features of TILCO-FIN design.

The VALUE of TILCO-FIN

The high heat transfer of TILCO-FIN allows a coil design of maximum BTU delivery without increasing the size or weight beyond workable limits. Often these are the determining factors in the marketability of a heat exchanger device. The low resistance of TILCO-FIN allows a greater depth of coil or unit without increasing the allowable static. Resulting smaller face areas allow smaller ducts, higher air speeds, less fan power and less power consumed to operate the device, all of which means lower cost per BTU delivered.

TILCO-FIN is now being used in a wide variety of heat exchanger fields. Users report it to be a superior extended surface which is helping them build and market superior products.

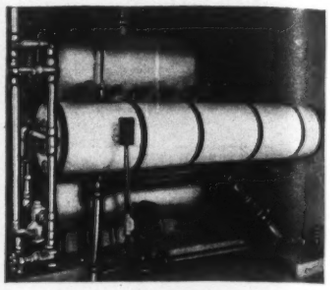
TILCO-FIN INCORPORATED

58 Second Ave., Brooklyn, N. Y.

Tankless Heater

No. 1928—The "Flo-Line" tankless heater illustrated is offered for buildings requiring a large volume of domestic hot water during heavy heat demand periods. While similar to the maker's "Hi-Flo" in construction, it is installed entirely below the boiler water line.

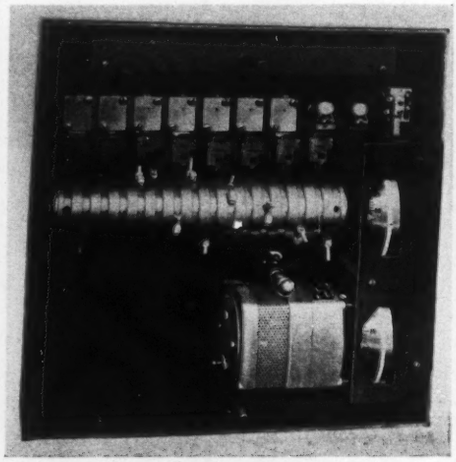
A circulator controlled by an electric aquastat inserted into the shell insures a rapid transfer of heat from the boiler water to the domestic water. During periods of no draw, the boiler water circulates through the shell by gravity through a bypass. A check valve closes whenever the circulator is operating to prevent a short circuit.



These heaters are available in capacities ranging from 340 to 1660 gph, 40 to 140 F, with boiler water at 180 F.—Taco Heaters, Inc., 342 Madison Ave., New York, N. Y.

Operations Timer

No. 1929—Precise timing of the sequence and duration of operations involving temperature, pressure, humidity or combinations of each often means success or failure for many industrial processes. The new "Flex-O-Timer" permits maximum precision of timing with minimum labor and expense, according to the manufacturer, and is adaptable for all electric, all pneumatic operations or combinations of both.



A typical use of the instrument in the air conditioning field is reversing the circulation of air in dryers according to a definite sequence.

Flexibility is obtained by the use of adjustable pins on the revolving drum which may be easily and precisely adjusted in circumferential undercut grooves and locked in place with a screw. The air valve or switch can be turned on and off, or vice versa, within one-half of 1 per cent of total cycle time by this means, it is stated. A new latch-trip solenoid operated mechanism is used to start the process instantaneously. Another feature is a new low leak air valve utilizing 99½ per cent of the air passing through it.

Where diversity of products processed requires considerable variation in processing time, the device offers a varying drum speed rotation.—Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.

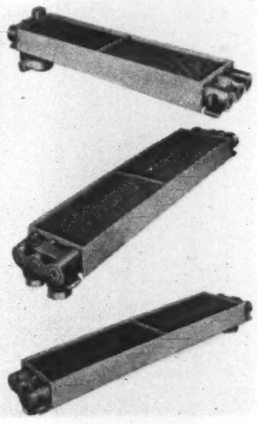
Spray Nozzle

No. 1930—The "Fulljet" spray nozzle is available in brass, but other materials can be specified. Pipe connection is ½ in. male and capacity is 2.5-2.9 gpm at 10 lb pressure.

The nozzle produces a full cone square spray with uniform distribution, the maker states, and also can be furnished with a round spray pattern. It is used for various industrial and chemical processes, gas washers, evaporative condensers, etc.—Spraying Systems Co., 4021 W. Lake St., Chicago, Ill.

Convectors

No. 1931—The 1940-41 "Convectofin" line for room heating is suitable for any regular piping system as there is a convector model designed to give the most heat output in any particular service, according to the manufacturer. They employ uniflow circulation and are available in three models: (1) The "Simplex" for single pipe straight steam, in sizes 10 to 90 sq ft. (2) The "Waterflo" for hot water heating, gravity and mechanical circulation, 10 to 90 sq ft. (3) The "Standard" for two pipe systems, 10 to 100 sq ft ratings.



The heating elements are of copper fin and tube construction with cast iron headers.—Commodore Heaters Corp., 11 W. 42nd St., New York, N. Y.

Safety Gage Covers

No. 1932—Safety is the most important of several features of the new "Durafront" plastic gage covers announced recently. According to the manufacturer, they "put safety goggles on gages."

They are molded of clear plastic with a tensile strength of 5000 lb and a compression strength of 15,000 lb. According to the maker, they increase the visibility or readability of gages and give them a modern streamlined appearance. Available in 3½, 4½ and 6 in. sizes.—Ashcroft Gauge Div., Manning Maxwell & Moore, Inc., Bridgeport, Conn.

Remote Control for Motors

No. 1933—A new system of electric remote control has been adapted to the "Varidrive" motor which makes possible the automatic control of the take-off shaft speed by means of a thermostat, float switch, etc.

The control consists of a small worm gear reducer mounted on the motor control case and connected to the control shaft which changes the speed. The pilot motor is operated by thermostat, float switch or similar control through a cyclic relay or process timer. The thermostat or float switch controls the direction of speed change while the cyclic relay governs the rate of change of the speeds.—U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif.

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Insulates Better

Absorbs 70% of noises • 75% Thermal Insulating Efficiency K Factor .27 B. T. U. • Prevents Condensation, Sweating Ducts or Rust • .f 0.0001322 Frictional Coefficient for free air flow • Moisture Proofed • Built to last, no chipping, flaking, rotting or cracking.

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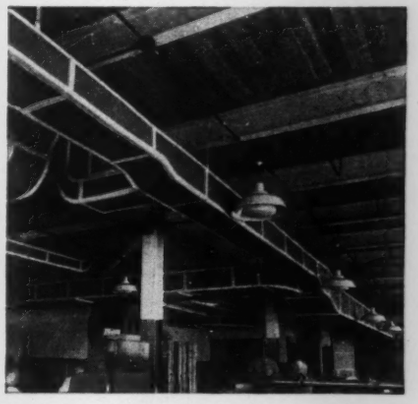
Flexible • Apply to inside or outside of round, irregular or rectangular ducts • Cuts with knife or snips • No waste • No lugs, bolts, screws, or wire to bother with • Easy to handle on the job.



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Nothing else to buy • Dux-Sulation comes in a roll 36" wide containing 100 square feet including adhesive for applying, and Asbestos Protected corner and joint strips • Packaged for easy stocking, shipping and handling.

For a balanced Air Conditioning, Ventilating or Heating job specify and use Asbestos Protected Dux-Sulation on all ductwork.

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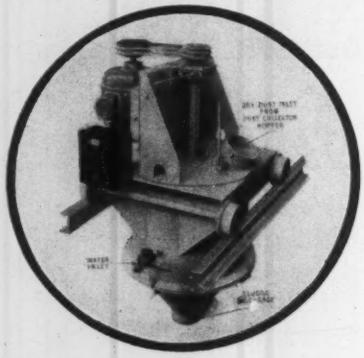
ATLAS ASBESTOS CO., LTD.
110 McGill St. MONTREAL, CANADA

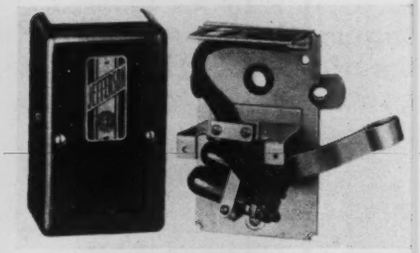
Dust Collectors

No. 1934—A new assembled type "Dustube" dust collector is recommended by the manufacturer for use where relatively small volumes of air—from 270 to 1440 cfm—are to be handled. The equipment is suited for collection of dust created by sand blasting, tumbling, grinding and similar processes. It is similar to the manufacturer's larger collectors of this type, but is equipped with a hand operated shaker and a bin hopper.



The same manufacturer has also announced a wet disposal unit for dry type dust collectors. It is designed for wetting and mixing with water or other liquids the collected dust discharged from the hoppers of dry dust collectors to give the maximum over-all result with dust collecting equipment.—American Foundry Equipment Co., 619 Byrkit St., Mishawaka, Ind.

Control Switch

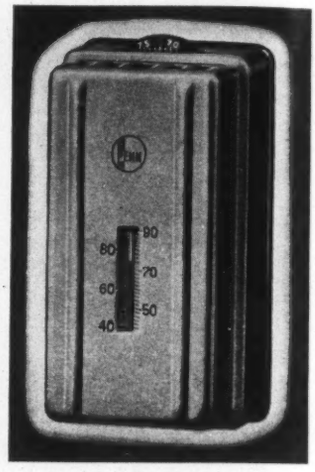


No. 1935 — An "all-round" control switch in which circuit is made and broken inside ferrotube mercury contacts has been added to the maker's line of pressure and float switches. These switches can be operated by hand, foot treadle, float or pressure in connection with signals, relays, etc.

It can be furnished with one mercury contact for single pole or a pair of contacts may be used for double pole make and break, or for controlling two separate circuits. Capacity—Up to 1875 watts per mercury contact (resistance load) on circuits up to 440 volts a-c and 250 volts d-c for ¼ hp a-c split phase motors, ½ hp a-c capacitor motors and ¾ hp a-c repulsion motors.—Jefferson Electric Co., 25th & Madison St., Bellwood, Ill.

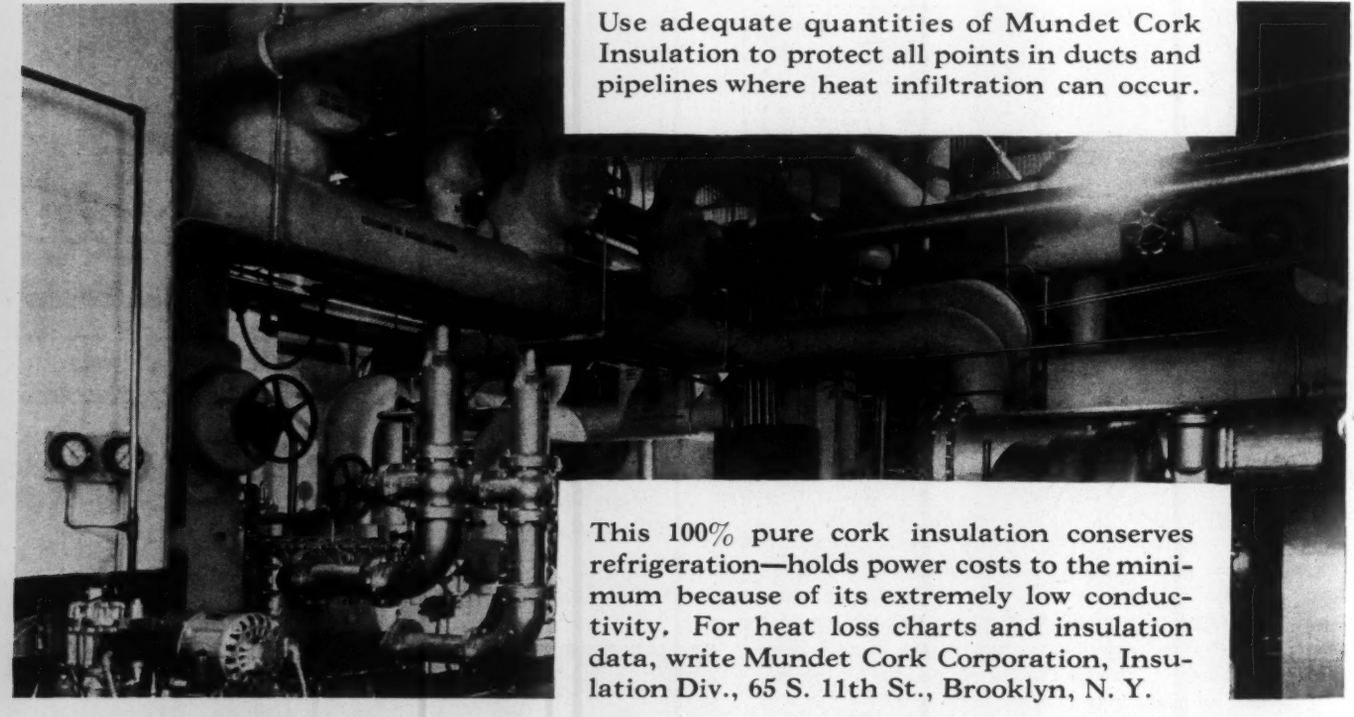
Heat Anticipating Thermostat

No. 1936—A new two wire, low voltage, heat anticipating or auxiliary heat actuated thermostat for all comfort heating applications was recently announced. Known as the "870 Series," it replaces the maker's former "Type 836" thermostat. It also is available for automatic day-night control when used with the day-night "Tem-Clock."



Advantages claimed by the maker for this new thermostat include a one piece moulded bakelite base designed for three point mounting to eliminate problems of base distortion; terminals set in recesses moulded into the base to eliminate possibility of shorting across the terminals with stray strands of low voltage wires; the use of a powerful, though small, Alnico magnet in the permanent magnet

For Cost-Saving Efficiency in Air Conditioning



Use adequate quantities of Mundet Cork Insulation to protect all points in ducts and pipelines where heat infiltration can occur.

This 100% pure cork insulation conserves refrigeration—holds power costs to the minimum because of its extremely low conductivity. For heat loss charts and insulation data, write Mundet Cork Corporation, Insulation Div., 65 S. 11th St., Brooklyn, N. Y.

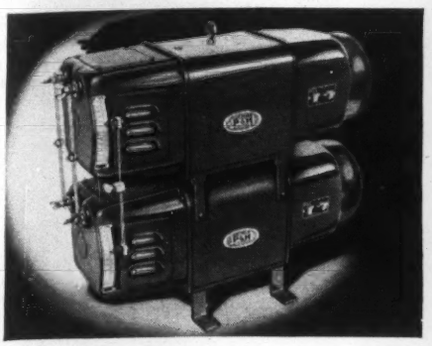
MUNDET Cork INSULATION

snap-acting contact; and a convenient sealed calibration adjustment.

This thermostat is designed for use with all of the maker's small motor relays and primary controls for oil, gas and stoker heating service.—Penn Electric Switch Co., Box 556, Goshen, Ind.

Parallel Hook-Up for Welders

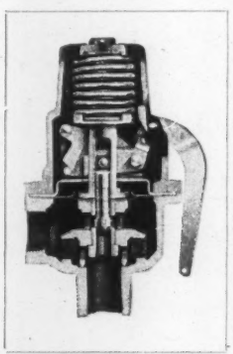
No. 1937—A new paralleling arrangement to combine the capacities of two or more "P&H-Hansen WD-150" welders has been developed. With it, an operator has at his disposal the aggregate current of two or more machines for peak loads. When the connection is "cut," each machine can be used separately by individual operators. Sets of two or more of these welders are obtainable for parallel operation and their square frame design enables them to be stacked one above the other without special structural framework.



Current selection is accomplished by a single control, the generator automatically responding with the desired current. With the new device, the single current control is carried over to the combined machines. The selector of each machine is connected to that of its fellow machines by means of a "multiple shifter," which when set for a given current, automatically sets the connected machines at that amperage.—Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.

Safety Valve for Hot Water Boilers

No. 1938—A new type of relief valve for hot water heating boilers has been announced. It has only two positions, according to the manufacturer—wide open or tight closed. When the pressure reaches 29 lb it snaps wide open and stays open until it drops to 22 lb. Its wide open orifice has relief capacity to prevent positively any pressure above 29 lb, it is stated.



A cam and roller construction carries out the snap action idea. When the pressure acting on the bellows reaches 29 lb, the tip of the cam slips past the roller, permitting a lever to trip the valve wide open, passing the full discharge capacity of the orifice. The flexible metal bellows assures sensitivity of response at the relief pressure, is durable and permits compact construction, the maker states.

Other interesting departures from conventional design are found in the hardened stainless steel valve, the metal to metal seal above the cone which protects working parts when valve is discharging, and the factory adjustment which is said to prevent tampering. The valve is ASME approved.—McDonnell & Miller, 400 N. Michigan Ave., Chicago, Ill.

Window Ventilator and Filter Unit

No. 1939—The new "Model M" window ventilator and filter unit illustrated is offered to provide positive control over the volume of air introduced into a room. The fan speed control is continuous from high to very low, according to the manufacturer. All moving parts are rubber cushioned and balanced as a unit

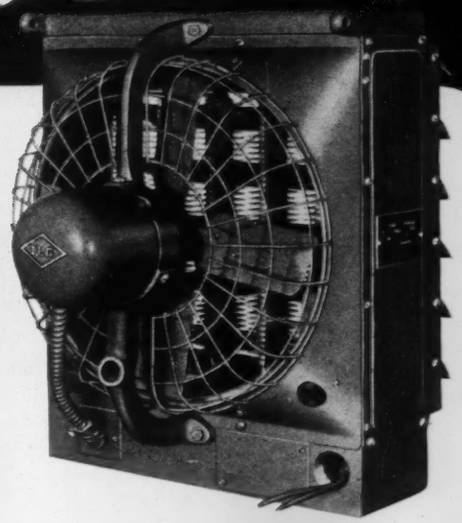
PIONEERING ILG LEADERSHIP

"Firsts"

NUMBER 4 OF A SERIES

WITH SELF-COOLED MIRACLE MOTOR THAT "BREATHES"

Never "Slow Roasts"



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UNIT HEATERS

'Way back in 1917, shortly after placing the first steam unit heater on the market, ILG met the demand for a self-contained electric unit heater. Incorporating the major features which made ILG steam unit heaters an instant success, the electric models eliminate the central heating plant, pipe lines and caretakers . . . give clean, safe, dependable heat instantly and uniformly at the turn of a switch. Made in two types, with sizes ranging from 1½ to 60 KW. Efficiently, economically, effectively heats the "Vital Zone" where people work, shop and play. Write today for Catalog No. 128.

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★ Floated drive for blowers—1932
★ Variable air control for blowers—1926
★ Type C (condenser-type) Motors—1925
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★ Automatic shutter—1907
★ Motor operated shutter—1918
★ Solenoid operated shutter—1907
★ Propeller fan steam unit heater—1916.
★ ILGATTIC system of summer cooling—1918
★ Portable type kitchen ventilating fans—1918
★ Built-in type kitchen ventilating fans—1925
★ Transom type kitchen ventilating fans—1925

SPECIFY "FIRST" FOR BUILDINGS WITHOUT STEAM OR HOT WATER

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★ Heavy-duty fan guard.
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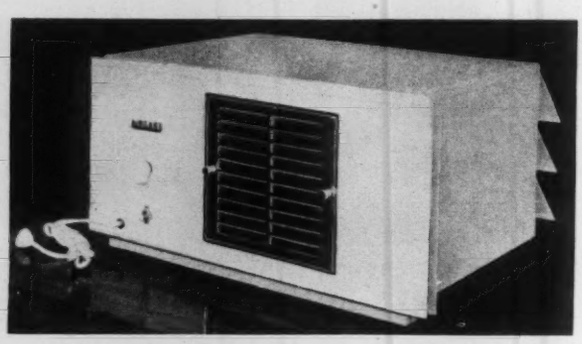
2841 N. Crawford Avenue, Chicago, Ill.
OFFICES IN 42 PRINCIPAL CITIES

ILG

UNIT HEATERS

to assure vibrationless operation and there are special acoustic liners in the cabinet to eliminate internal noise and prevent street noises from entering.

A four position outlet grille to allow the air to be directed



upward, downward, to either side, or straight out is designed to eliminate drafts.

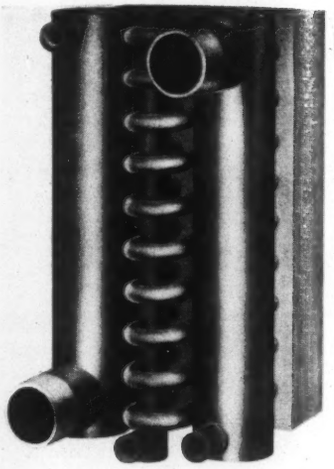
This unit may be installed in any double hung or sliding window over 18 in. wide, and there is no inside projection to the unit. It may also be installed in factory sash, casement and French windows.—Airgard Mfg. Co., 609 N. LaSalle St., Chicago, Ill.

Drainage of Water Type Cooling Surface

No. 1940—A new drainage feature is incorporated in the "Series W" water type cooling surface in order to insure water drainage in continuous or cleanable tube surface to a point where subsequent exposure of the surface to cold air will not cause damage from freezing. This feature is available in all sections of the surface; depending on the number of rows in the section, one, two or three drain headers are incorporated.

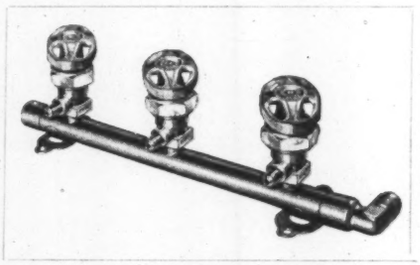
At the time of installation, the surface is given a pitch toward the inlet header to permit the first and last rows of tubes to be drained through the headers by means of the usual header and piping drains. The intermediate rows as well as the trapped bends are then drained through a special vertical header connected to all these bends.

This surface is intended for air cooling and dehumidifying with cold water or for air heating with hot water.—John J. Nesbitt, Inc., State Rd. and Rhawn St., Philadelphia, Pa.



Packless Valve Manifolds

No. 1941—A new line of manifolds incorporating the manufacturer's "balanced action" diaphragm packless valves for refrigeration, air conditioning and various industrial requirements has been announced. Their three-fold purpose is to provide a neat, compact, convenient means of mounting shut-off valves, to provide even distribution of fluid through the various valves and



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—the CONTRACTOR Has Only ONE Thing to Buy
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STRENGTH
SIMPLICITY
REAL PIPE SUPPORT AND GUIDE SCREW INTO CONDUIT — REMOVABLE
PIPE AND ITS COVERING FREE FROM ANY LOAD ON THE CONDUIT
HEAVY ASPHALT SHELL IS OUTSIDE OF AND SUPPORTED BY STRONG ARMCO CONDUIT
CROSS SECTION
DURABLE WATERTIGHT ENGINEERING
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Armco Iron Conduit is the foundation supporting heavy asphalt shell of any desired thickness—a permanent housing, with ample structural strength, lightweight and watertight. Furnished in any lengths, with any kind of pipe or insulation, for underground or overhead steam lines. *Welded* couplings used if preferred. A complete, self-contained, *streamlined* system —MADE POSSIBLE ONLY BY MODERN ENGINEERING. Write for latest Bulletin.

THE Ric-wiL CO.
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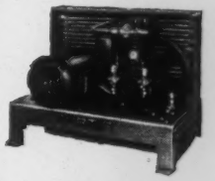
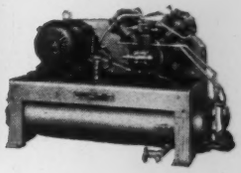
CURTIS Condensing Units



48 Air Cooled Units—
45 Water Cooled Units
—1/6 to 30 h.p.



Selective Fitting of Pistons to Cylinders!

The cylinders in CURTIS compressors are gauged with a Swedish Cylinder Gauge. The pistons are similarly gauged with a Sheffield Visual Gauge, pistons and cylinders being matched within tolerances of .0001 (one ten-thousandth) of an inch.

Such segregation and subsequent matching of piston to cylinder assures the most accurate fit. The result is better compression, quieter operation, less wear, and longer life for these important parts of the unit.

Selective fitting of pistons to cylinders is only one of many tests and operations that are characteristic of Curtis precision manufacturing methods. All contribute to the long life, high efficiency and exceptionally trouble-free performance of every Curtis Condensing Unit.

CURTIS REFRIGERATING MACHINE COMPANY
Division of Curtis Manufacturing Co.
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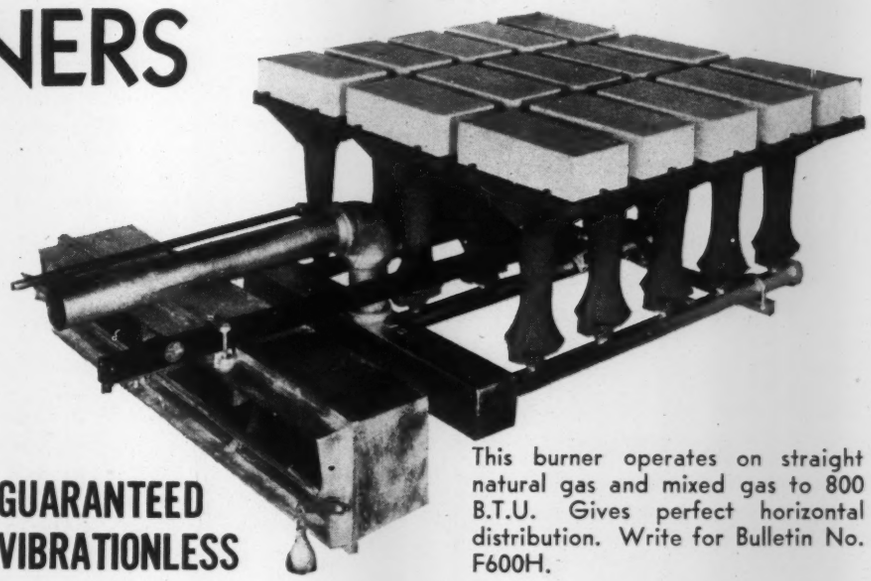
CURTIS REFRIGERATION AIR CONDITIONING AND COMMERCIAL

WECO-N.G.E. Series F600 GAS BURNERS

These burners are available for ratings from 50,000 to 10,000,000 B. T. U. output, for use in heating boilers, power boilers—in any metal firebox or sectional boiler. Featuring flexibility to meet various firebox shapes and sizes at various gas pressures, and low draft loss. Full automatic controls that operate properly can be easily applied.



GUARANTEED VIBRATIONLESS

This burner operates on straight natural gas and mixed gas to 800 B.T.U. Gives perfect horizontal distribution. Write for Bulletin No. F600H.

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Surface Combustion Corp. . . . . Toledo, Ohio

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DIRECT READING CHARTS

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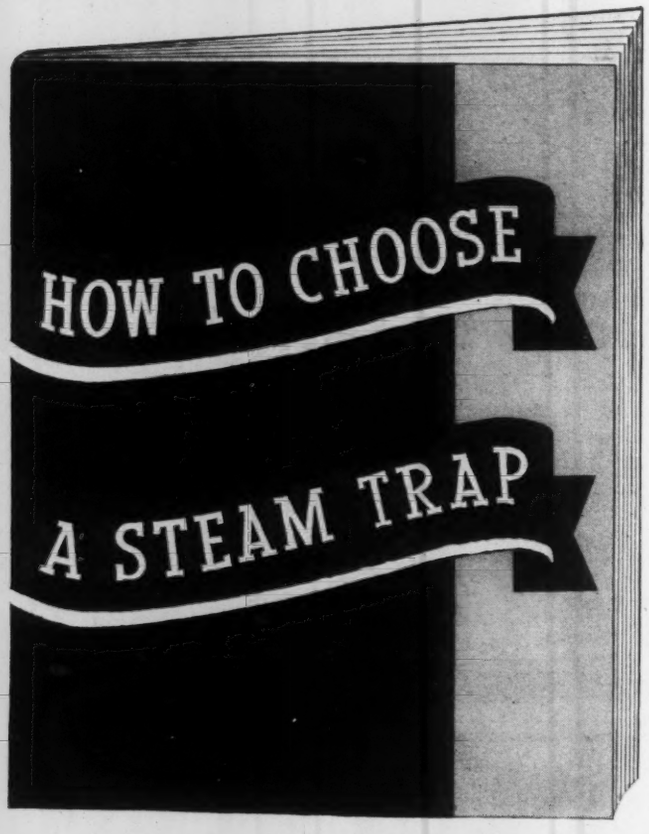

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"How To Choose A Steam Trap" is a convenient, informative book. Condensation rate charts, graphs and tables—short formulas for computing condensing capacity of steam using equipment—trap sizes for unit heaters, autoclaves, header drips, jacketed kettles, etc., all this and more is included in this helpful, new steam drainage guide.

Save time and trouble—don't deny yourself the aid of this handy volume—send the coupon today for your free copy of "How To Choose A Steam Trap."

THE V. D. ANDERSON CO., *1949 West 96th Street, Cleveland, Ohio*

I would like a copy of the book "How To Choose a Steam Trap," and I understand that this does not obligate me in any way.

Name..... *Company*.....

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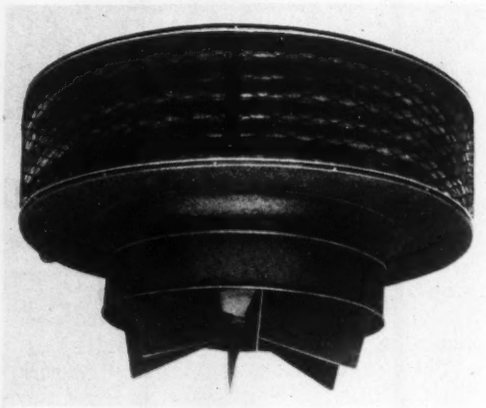
lines, and to allow centralized manual control location.

The principal feature is the new non-directional valves with a balancing action feature to assure positive opening under all pressure conditions. Oval handwheels are standard.

Sizes of valve connections range from ¼ to ⅝ in. SAE flare or OD solder. Sizes of elbow manifold connections range from ⅜ in. SAE flare to 1⅜ in. OD solder.—Henry Valve Co., 1019 N. Spaulding Ave., Chicago, Ill.

Vertical Type Unit Heater

No. 1942—The new vertical type unit heater illustrated has been especially designed for systems requiring ceiling mounted units. It is offered for high or low ceiling applications in commercial and industrial establishments and is manufactured in 12 sizes, with capacities ranging from 30,000 to 600,000 Btu per hr (2 lb steam pressure and 60 F entering air).



The heating element is designed to operate on steam pressures from 1 lb up to a maximum of 150 lb saturated. All two speed motors are furnished with two speed controllers, and the low speed is approximately 65 per cent of synchronous speed with cfm varying directly as the rpm. Variable speed one phase motors are furnished with transformer controller, and low speed is approximately 50 per cent of synchronous speed with infinite number of speeds between high and low speed.—American Blower Corp., 6000 Russell St., Detroit, Mich.

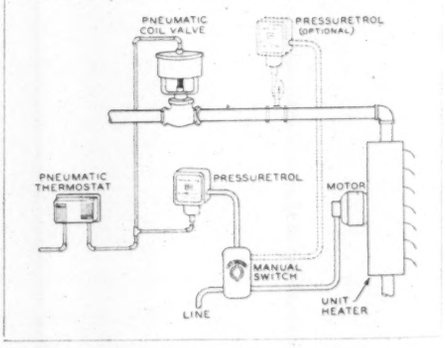
Unit Heater Control System

No. 1943—A new unit heater control system provides, according to the manufacturer:

1) Modulated continuous flow of steam whenever the thermostat is calling for heat, the quantity of steam flow being dependent on the demands of the thermostat.

2) Continuous automatic fan operation only when steam is being supplied to the unit heater.

3) A manual "off - on automatic" switch in order that the fan may be run constantly or if no heat is required it may be shut off entirely.



The system may be either pneumatic or electric, the former being recommended by the maker as more desirable in industrial buildings where a compressed air supply is available.—Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave. S., Minneapolis, Minn.

★ *Accurate*

★ *Convenient*

★ *Complete*

. . . That's the story behind the success of HEATING, PIPING & AIR CONDITIONING'S Annual Directory, published each January. Its completeness, accuracy and convenience have made it indispensable to engineers and contractors throughout the year for reliable reference in their buying and specifying work.

An authoritative up-to-date listing of all the products that go into "big building and industrial" heating, piping and air conditioning systems . . . names of all manufacturers who make them, trade names and addresses . . . part of regular January issue . . . bound in special, heavy, varnished cover to stand up against wear and tear of constant use . . . out early in January for service throughout 1941 . . . final forms close December 20.

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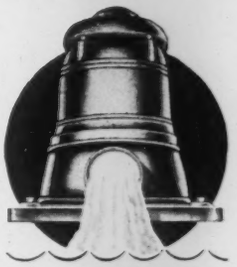
WELLS AND PUMPS



When you buy a Layne Well Water System, you can be assured that it will give you long years of excellent service. In addition to using the very best quality in materials, Layne also provides special types of metal for submerged parts. This infinite attention to details is legion through the Layne organization and has served to build a world-wide reputation for the dependability of Layne wells and Pumps.

At this time there are many plans being drawn for expansion and much actual building is already under way. Would it not be wise to give extra attention to your water problems By direct comparison with any equipment on the market, you will find exclusive and outstanding features in Layne wells and pumps. Year by year and dollar by dollar, Layne offers you the best value.

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For Municipalities, Industries, Railroads, Mines and Irrigation

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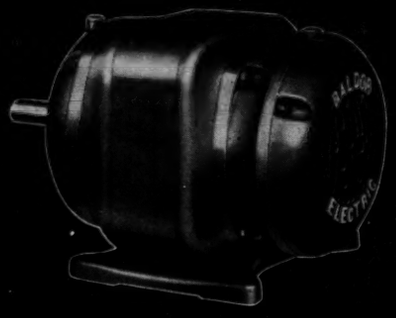
YEAR-AHEAD MOTOR



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STREAMCOOLED. Provides a ball bearing totally enclosed protected motor with a non-clogging cooling system.

GLASS INSULATED. Permits more horse power in the same space and longer life under abusive service.

NO EXTRA COST. Baldor streamcooled motors, in either standard insulation or glass insulation at ordinary open motor prices.

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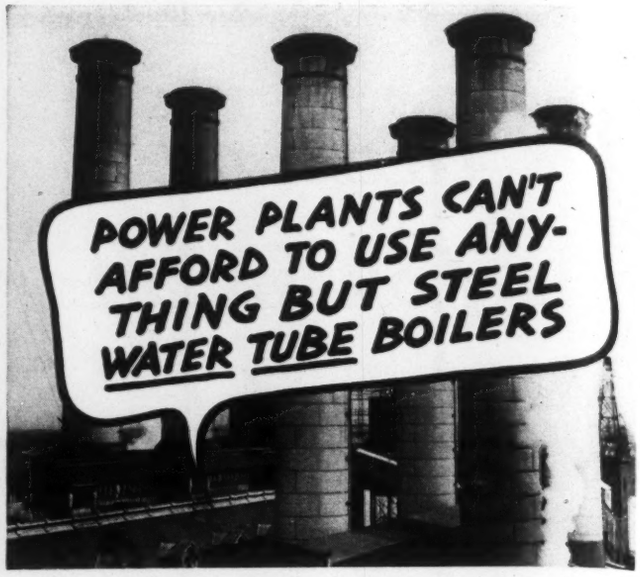
BETTER MOTORS



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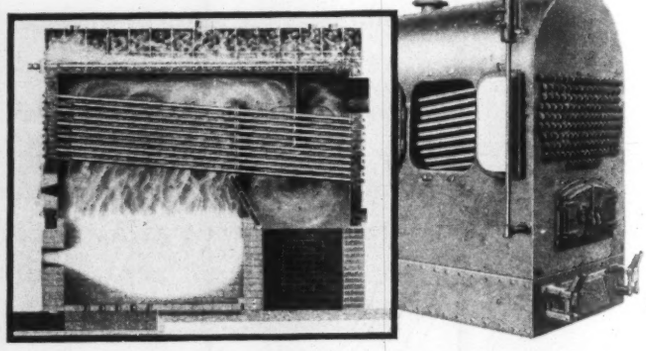
Today, the conservation of fuel is becoming more and more important. International Water Tube Boilers have earned the name of "FUEL-SAVER" because they are designed for complete absorption of hot gases, rapid and positive internal water circulation, and quick steaming. The result is great flexibility and low stack temperature under *all* load conditions.

Now is the time to become fully familiar with the superior advantages that steel water tube boilers have brought to the heating, industrial power and processing fields.

Showing cross-section of Oil Fired Setting; also available for Stoker and Hand Firing. Offered in a complete line of residential, commercial and industrial boilers. See catalog in Sweets.



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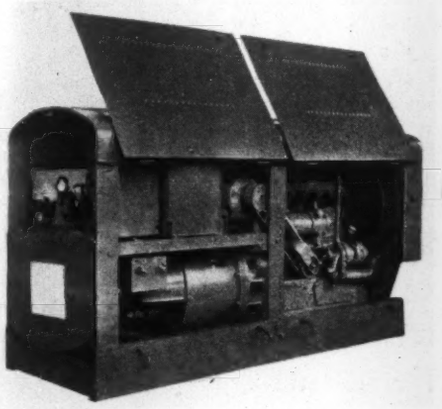
11 Birch St., East Stroudsburg, Pa.
Established 1886

"FUEL-SAVER"
WATER TUBE
STEEL HEATING & POWER BOILERS

400 Amp Arc Welder

No. 1944—The application of gasoline engine starting on diesel driven arc welders, announced previously on a 300 amp unit, has been further extended and is now available on a 400 amp model. This advance makes available easy starting in any weather and the inherent economies of diesel drive in the many applications for engine driven welders of capacities up to 400 amp, the maker states.



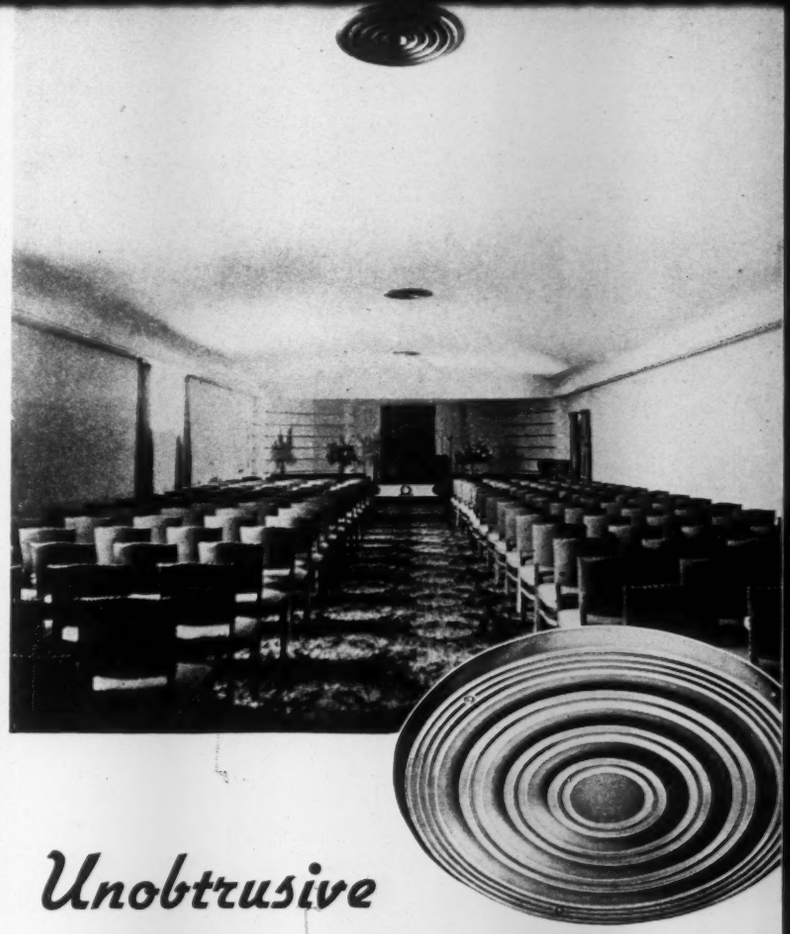
Fuel oil consumption is reported as 1.5 gph at full load operation. In addition to its operating economy, the diesel engine compares favorably in simplicity, weight and cost, as well as operating speed.

The gasoline starting engine is a small auxiliary mounted above the diesel. It is started by means of a hand crank. A belt drive, engaged by means of a clutch, connects the starting engine to the diesel. Starting in extremely cold weather is facilitated by having the cooling system of the small starting engine connected into the cooling system of the diesel. This permits warming up the diesel by running the starting engine a short time and allowing the heated water to circulate through the diesel engine.—Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio.

Air and Vacuum Valves

No. 1945—Incorporated in the construction of the new "Airovent" automatic air valve and the new air and vacuum valve are such features as wide range adjustable venting, multiport silent venting, leakproof and spitproof operation, rapid venting of air, and modern streamlined appearance, says the manufacturer. The vacuum feature includes a check which prevents return of air into the valve when condensing steam begins to form a vacuum; as the vacuum force increases, the internal diaphragm expands and closes the valve from the inside.

The air vent port is deep in the heart of the valve in order to silence the passage of high velocity air. A baffle plate is incorporated to prevent spitting and spurting, and a separate float chamber permits the valve to drain before opening the port. The venting rate is adjustable by means of a calibrated scale.—Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.



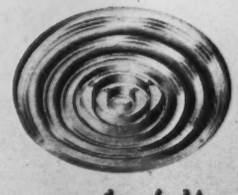
Unobtrusive

IN THESE QUIET SURROUNDINGS

Notice how unobtrusively the Aerofuse Outlet becomes a pa of the dignified room pictured above. This flush type ceili diffuser is so simple in design that it may be used equally w with any style of decoration. But the Aerofuse Outlet is f more than a thing of beauty! The great reason for its growi popularity is its functional superiority, providing (1) Maximu Air Mixture; (2) Rapid Temperature Equalization; (3) Perfe Air Distribution; (4) Total Elimination of Drafts.

AEROFUSE OUTLET

We have prepared an 8-page brochure which fully details the Aerofuse Outlet, gives an easy-to-use selection system, list prices and all other data pertinent to its use. If you haven't a copy send at once.



. . . . And Now

A SUPPLY AND RETURN UNIT

Valuable in installations where simplification of the duct layout is of primary importance. Supply and return (exhaust) ducts can be run to the same point.

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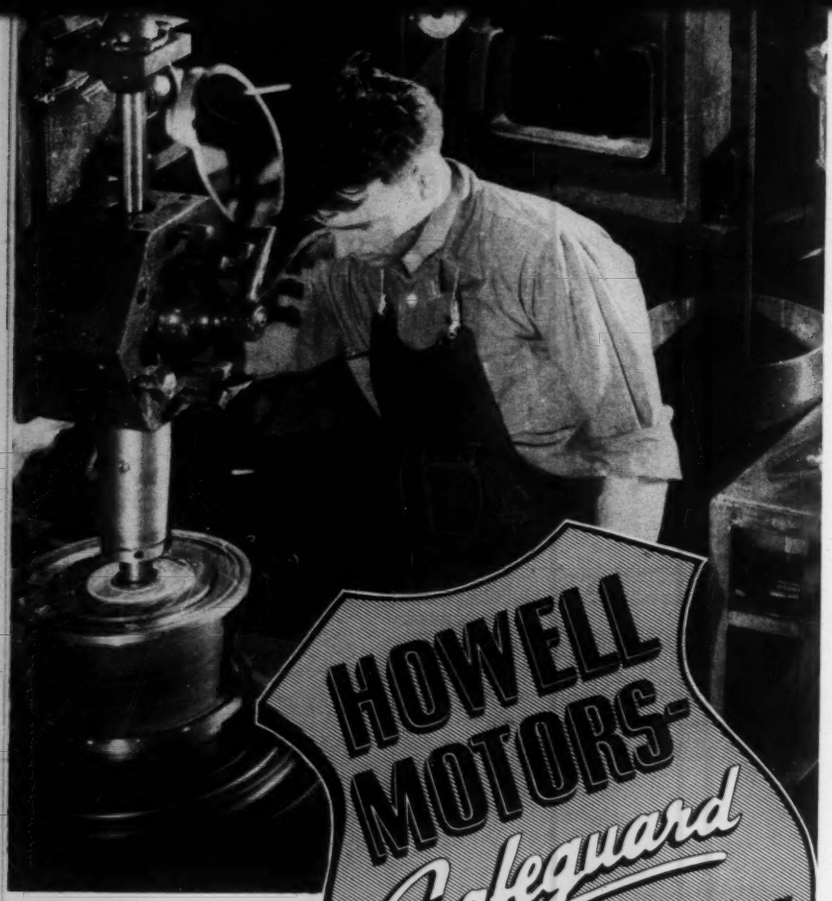


EXAMPLES OF PRECISION

One in a Series of Advertisements, "HOWELL Motors in the Making"—showing how modern precision standards maintain HOWELL quality. . . .

STATORS and ROTORS are GROUND FINISHED

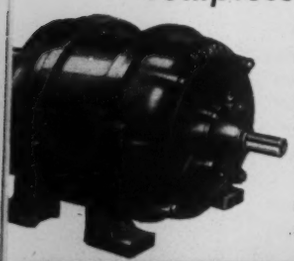
. . . Insuring Uniform Air Gap

Photograph above illustrates how stator bores are ground at HOWELL—a precision operation kept within tolerances of .001 inches. Rotors are also given a ground finish of the same exacting nature.

Precision manufacture of both stators and rotors guarantees that every HOWELL Motor has a uniform air gap. This uniform air gap reduces vibration and noise, increases efficiency, and assures long bearing life.

The close tolerances maintained in the construction of HOWELL Motors makes for QUIET OPERATION, and trouble-free performances despite the severity of service conditions.

Complete Line — Fast Delivery



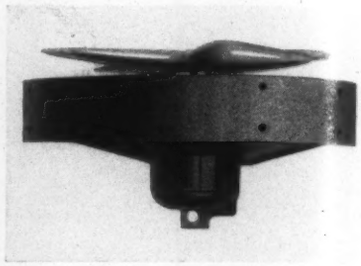
For 25 years HOWELL has specialized on polyphase motors for air conditioning, ventilating and heating drives. Motors can be furnished with any electrical and mechanical characteristics required — ½ to 150 HP, single or multi-speed.

Whatever your drive needs, HOWELL can meet them EXACTLY and on time. Write us, outlining your particular problem!

HOWELL ELECTRIC MOTORS COMPANY
HOWELL, MICHIGAN
Representatives in All Principal Cities

Roof Ventilating Fans

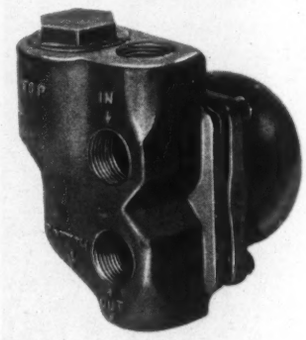
No. 1946**—New power roof ventilating fans, recently announced, are recommended by the maker for use where it is necessary to increase air removal or when wind velocity is not sufficient to ventilate a building. They are available in 48, 42, 36, 30, 24 and 18 in. sizes with air exhaust capacities ranging from 40,000 to 2000 cfm.



They are mounted in steel bands as illustrated. Propellers are made of high quality cast aluminum alloy.—Truflo Fan Co., 523 Main St., New Harmony, Pa.

Float and Thermostatic Trap

No. 1947—Redesign of the "Model 69 Sterlco" float and thermostatic trap has been announced. With increased capacity ranges, it is suitable for steam conditions from 25 in. vacuum to 20 lb pressure, according to the maker, who states that it will handle 400 lb per hr of water at 2 lb steam pressure, and 1200 lb at 20 lb pressure.

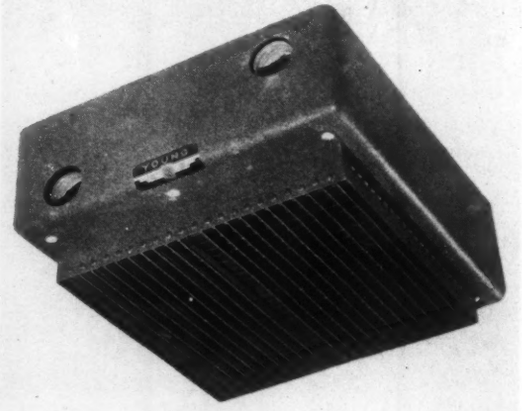


Air is vented continuously by means of a bellows controlled valve at the top of the trap; a separate water outlet is controlled by a copper float in the trap body. Two inlets on the side and top, and two outlets on the side and bottom, permit assembly into the line in a number of different piping arrangements. Removal of four cap screws permits access to operating parts without disturbing pipe connections.—Sterling, Inc., 3738 N. Holton St., Milwaukee, Wis.

Unit Heaters

No. 1948—A complete new line of "Vertiflow" unit heaters designed particularly for industrial buildings, stores, etc., having high ceilings, includes 12 sizes varying in capacities from 63,000 to 480,000 Btu per hr. These units may be installed high above the floor close to the ceiling to eliminate air stratification and assure little difference between floor and ceiling temperatures, according to the maker.

The illustration is a three-quarters "worm's eye" view of one of these suspended units. Note the air directing louvers controllable to any air deflection or splay spread desired.—Young Radiator Co., 709 Mead St., Racine, Wis.



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288 Pages—Illustrated
$2.50

Here is a book that presents—in simple, readily understandable form—every kind of information necessary for an accurate and thorough knowledge of air conditioning principles, equipment, and practices. Written by S. R. Lewis, a widely-known consulting engineer who has been active in air conditioning work for more than thirty years, it deals with all angles of the air conditioning subject from the practicing engineer's viewpoint. The designing procedures explained in the book are, for example, in every detail the same procedures employed today by the author's own organization.

Featuring this third edition are several entirely new chapters on phases of the subject not previously treated, including noise control, air conditioning measurements, air conditioning standards, fire protection codes and operating suggestions. Brand new designing examples are also used, together with new forms for recording the design data, the proper filling-in of which is explained step-by-step.

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Engineers in air conditioning will find the new "Air Conditioning for Comfort" invaluable as a reference book, while salesmen, students, and others may rely on it to give them a clear knowledge of fundamentals, and of the latest air conditioning methods and equipment.

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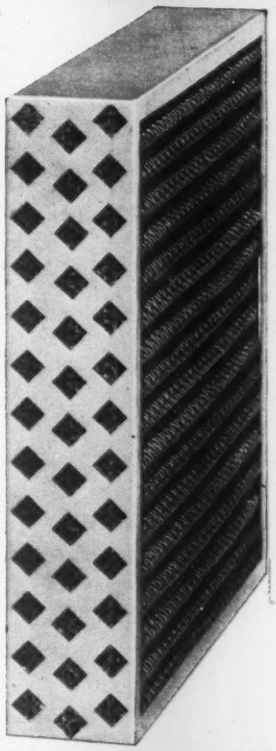
6 N. Michigan Ave. Chicago, Ill.

GET ON THE BANDWAGON

WITH
AIR-MAZE



THE BIG SWING IS TOWARD PERMANENT AIR FILTERS

Users today know more about air conditioning equipment . . . and expect more. They know that they can't have maximum performance without thoroughly efficient air filter panels . . . permanent, cleanable air filter panels.

Naturally, the customer is the boss and this explains why manufacturers and dealers in air conditioning are swinging more and more to AIR-MAZE air filter panels for initial installation.

With their tested efficiency of 99.3% to 99.83% AIR-MAZE panels insure dependable trouble-free performance throughout the life of the air conditioning system. They are more economical, too, in the long run because they need no replacement. An occasional cleaning . . . taking only a few minutes . . . makes AIR-MAZE panels like new again, ready to continue their top-notch performance.

APPROVED BY THE UNDERWRITERS' LABORATORIES
AIR-MAZE panels are of scientific all metal construction, sturdy, odorless and *approved as fire retardant by the Underwriters' Laboratories.* They give your customers everything they have a right to expect.

LET US HELP YOU SOLVE YOUR AIR FILTER PROBLEMS

AIR-MAZE filter panels come in standard sizes or can be furnished in any special sizes and shapes to meet unusual applications. Let us supply helpful data on your problems.

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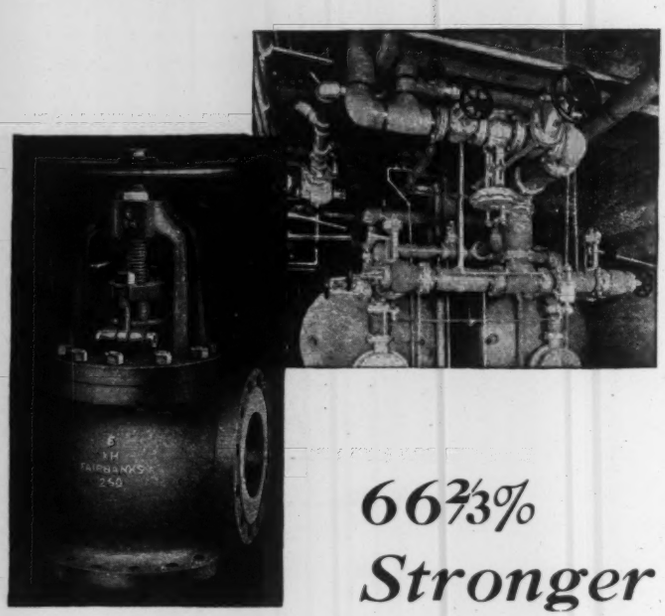

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Fairbanks Iron Valves are made of a special high-test alloy iron which has a tensile strength of 40,000 lbs. per sq. in. This is about 66 2/3% greater than ordinary cast iron, giving greater strength to withstand pipe strains and sudden shocks.

The rolled naval bronze stem, with full cut Acme threads, makes the valves operate more easily. You will never have trouble opening or closing them.

When you need valves on which you can take no chances, especially for installations like the above De Paul Hospital, St. Louis, Mo.—where valve failure might curtail the water supply or fire-prevention systems and jeopardize the lives of hundreds of patients—install the dependable Fairbanks Valves.

Fairbanks Valves are made in bronze and iron for a large range of pressures, with screwed and flanged ends, in globe, gate, angle, check and cross patterns.

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Fairbanks Iron Valves

Industrial Health Defense

With the object not only of conserving the health of the worker but also of increasing efficiency and morale, the Air Hygiene Foundation is issuing a series of short "emergency reports" to its member companies. The purpose is to point out possible health hazards in this period of stepped up production and to suggest remedies.

The first of these reports follows:

Amid preparation for national defense, it is well to review the experience of World War I and to profit by lessons learned at that time.

Since preparation programs are usually belated, there is a temptation toward a headlong policy of blind haste which may lead to the needless waste of precious human strength. This should give way to a realization that increased output is gained through conserving workers' health and strength by increasing the working force, not by taxing endurance to the breaking point. In a long race it is endurance, not sprinting, that wins.

The fallacy of expecting output to increase in proportion to the hours worked was exposed during the last war. The publications of a British munitions health committee (a group appointed by the minister of munitions) point out that overtime must be limited. Extension of the usual hours of work does not—except for short emergency periods—result in a proportional increase in output; on the contrary, it causes the rate of output to fall with increasing rapidity. Modern industry has already learned the value of rest pauses as aids to health, contentment and efficiency. Foremen and higher executives even more certainly require definite periods of

Here's a Multiple Reason for using COCHRANE Back Pressure Relief Valves

. . . Cochrane's MULTIPORT Valve Principle

To provide absolute insurance against sticking, jamming, overweighting or tying down that are common to single disk valves, Cochrane Multiport Relief Valves are constructed with multiple disks which reduce individual disk port area, pressure, valve travel . . . and insure more responsive and continuously reliable operation. More than 12,000 steam plants depend on Cochrane Multiport Valves. Write today for Bulletin 2870.

Cochrane Corporation, 3131 N. 17th St., Philadelphia, Pa.

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rest. These individuals seldom spare themselves. They carry heavy responsibility and they cannot be replaced. It is of highest importance in the interests of the defense program that executives take that rest which is essential to the maintenance of health. Not all occupational diseases are caused by toxic dusts, fumes and gases; among executives, overwork and strain are important causes of heart disease.

The problem of potential toxic hazards must be thoroughly reviewed at this time. Not only will many new hazards be introduced, such as those associated with munitions manufacture, but many of the usual conditions will become doubly dangerous when workers are over exposed as a result of greatly increased plant output, overtime and pressure of work. It has been found, for instance, that workmen with an exposure to lead which under normal conditions is not dangerous, will under pressure of overtime and hastened production show increased numbers of basophilic cells in the blood (evidence of excessive lead absorption) due to the cumulative nature of this hazard. The body is able to throw off certain amounts of toxic material during the time away from the work place, but when the exposure is increased beyond this limit, acute or chronic poisoning may take place. Fatigue also plays an important part here. It has been said that lack of proper rest has a larger part in the inception and progress of disease than any other one factor.

Records of sick absences are doubly valuable right now. Any rise in the rates may indicate some defect in working conditions which calls for swift investigation and correction. The acute shortage of skilled labor in many

Thermal Bellows Units
FOR THERMOSTATIC UNITS

CLIFFORD MANUFACTURING CO.
564 E. FIRST STREET, BOSTON
BOSTON CHICAGO DETROIT LOS ANGELES
PRODUCERS OF BELLOWS EXCLUSIVELY
SERVING AUTOMATIC CONTROL MANUFACTURERS

Made in 9 sizes, with capacities from 10,000 to 29,200 sq. ft. steam.

Hank sez—

Here's a School Saving You Can't Laugh Off!

JUST because you hard headed engineering folks are so alfired skeptical, it makes me sort o' slow at times, to not lie a little, by not telling all the truth.

What am going ter tell you now, you can check up on me, by writing to the president of the board of education at Chester, N. Y.

They had a school on top of a hill where the cold winds come clean from the Shawangunk mountains and blow like billy-be-damned. It was het—or meant ter be, but never really wuz—by a kupple a direct coal fired hot air contrapshuns. The fuel bill was a scandal.

They put up with it fur 10 years. Then there wuz a chunk of repairs had ter be made. Instead of makin 'em, they left the contrapshuns be, and put in two Burnham 50 inch twin sectional boilers and burned oil. They never did run but the one.

But the board believed in having the extra one handy by, if t'other one ever got indigestion or sumpthin.

The talk wuz that there wuz a saving of more'n a third on fuel. Furthermore, they never had to send no children home fur fear of getting newmonia.

I could tell you more yet. But tain't likely you are believing what have told. So, what's the use of compounding no felony, or whatever 'tis you call double deck lying.

And don't forgit we are a member of the Boiler and Radiator Institute.

HANK HINDLE

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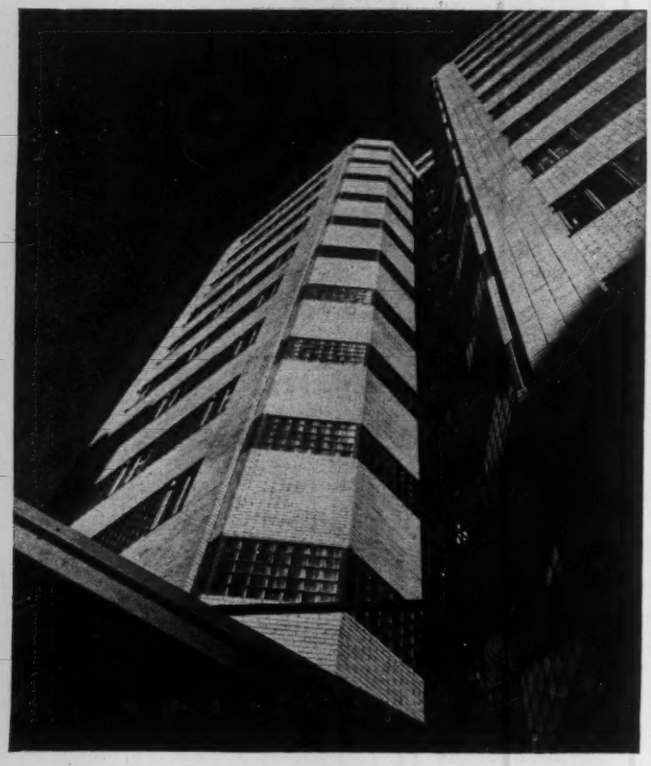
Burnham Boilers

No Rusty Hot Water in These Apartments



New York's First Complete Air Conditioned Apartment House

Architects, Frederick L. Ackerman—Ramsey & Sleeper, Associates; Consulting Engineers, Sullivan A. S. Patorno; General Contractor, Turner Construction Co.; Plumbing Contractor, J. L. Murphy, Inc.

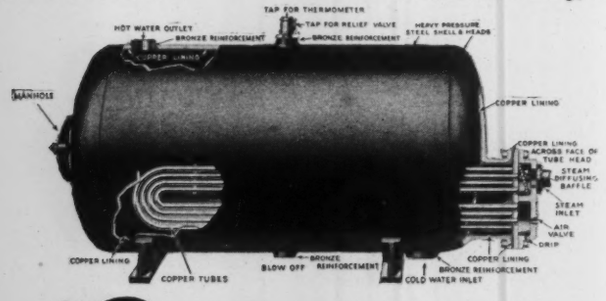
The Patterson Indestructo COPPER-LINED Hot Water Heaters in this modern apartment building at 25 E. 83rd Street, New York, can never rust and cause red water.

Moreover, they will not deteriorate from rust, therefore will outwear many ordinary heaters and yield greater returns on the investment, when measured by actual cost over years of service.

Be safe and install Patterson Copper-lined Heaters. Then, if necessary, you can always fall back on our guarantee that these heaters will not rust or cause red water and that they will deliver all the hot water required, as hot as required and as fast as required.

Write for our interesting catalog.

THE PATTERSON-KELLEY CO., INC.
107 Warren St. East Stroudsburg, Pa.



Patterson
Copper-Lined and Everdur Hot Water Heaters

lines will not permit a single worker to be lost in this program of industrial mobilization for defense. One factor which affected sickness records during the last war was that a large proportion of the most vigorous and robust men were called to the colors and their places taken by boys, older men, women, and physically inferior persons. As far as possible, rigorous medical supervision must be utilized to control this condition.

Methods of control for industrial hazards, such as exhaust systems which operated satisfactorily under normal conditions, may soon be overloaded by the pressure of increased production. Careful inspection and maintenance alone can keep such apparatus efficiently accomplishing its protective function.

A program of industrial building and expansion has already begun to take care of the increased productive activities. Precious time and money can be conserved if a little thought is given to the problem of mitigating and protecting against potential health hazards while these buildings are in the planning stage. Choice of location of machines and men, provisions for protective exhaust equipment, substitution of harmless for harmful materials wherever possible, are factors which can be allowed for in building plans.

Library Cleans Air Electrically

The new Virginia state library, Richmond, will be ventilated with electrically cleaned air. State authorities recently purchased five electrostatic air cleaning units having a total capacity of 57,750 cfm at a cleaning efficiency of 85 per cent on the "blackness test" basis speci-

MEMO

FROM: Sales Manager

TO: Adv. Manager

Please make a note of the important message about January 1941 in the September issue of HEATING, PIPING and AIR CONDITIONING.

P. S. You'll find it on pages 14 and 15.

fied by the National Bureau of Standards. The equipment will be used not only for removing dirt particles but also for precipitating minute particles of air-borne sulphurous compounds, which are said to be one of the most important factors in the deterioration of book papers.—T. J. ATKINS, Westinghouse Electric & Mfg. Co.

Standards Committee Dissolves

The Chicago committee on air conditioning standards, of which John Howatt, chief engineer of the Chicago board of education and member of HPAC's board of consulting and contributing editors, has been chairman, terminated its existence last month because its work has been completed. This committee formulated in 1934 a set of standards for comfort air conditioning. Since that time, national standards generally similar to them have been adopted by the ASHVE and other national organizations.

Unlike many committees, the group dissolved with assets in the bank. Contributions were therefore made to a newly formed committee which is investigating the hazards of explosions in hospital operating rooms. Dr. Selim McArthur, chief of staff of St. Luke's hospital, Chicago, is chairman and among the members of this newly formed committee are E. P. Heckel, Samuel R. Lewis and V. L. Sherman. A contribution was also made to the local chapters of the ASHVE and the ASRE to be used for a joint meeting of these groups.

General Series K-15 Magnetic Valves are readily installed on air conditioning or refrigerating equipment, handling air, gas, water, light oil, steam and all refrigerants. Positive opening and tight shut-off are assured. Designed for low and high pressure duty at full ported capacities. Available for any voltage AC or DC. For complete specification and capacities, *write for Catalog.*

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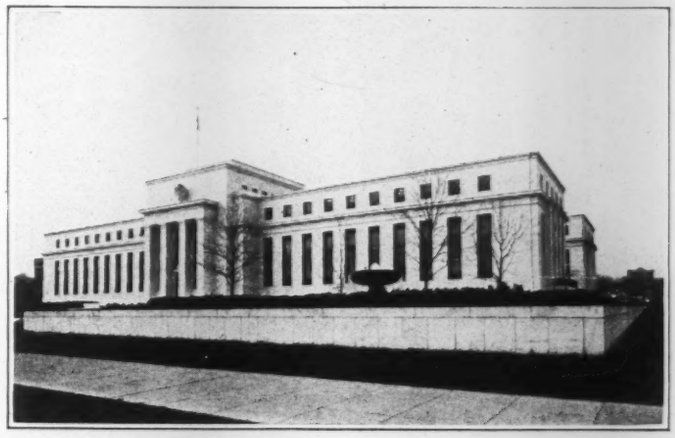
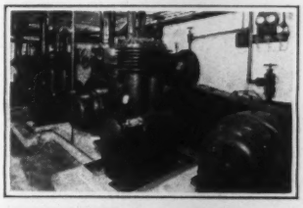


Two Fine New Buildings Equipped with

TRADE FRICK MARK

Refrigeration

Baltimore's Federal Land Bank Building is Air Conditioned by these No. 3 Frick machines.



Which provides cold drinking water and "cold" for restaurant service at the Federal Reserve Board Building, in Washington (shown at top), and complete air conditioning for the Federal Land Bank Building, in Baltimore (at left). Both installations are credited to the Paul J. Vincent Co., Engineers and Contractors, who are Frick Distributors.

You'll find Frick Refrigerating, Ice-making and Air Conditioning Equipment in thousands of important buildings, from Shanghai to Boston.

Let us quote on the cooling equipment you need: the public appreciates the benefits of modern refrigeration service. Write, wire or 'phone

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DEPENDABLE REFRIGERATION SINCE 1882

A New LINE OF

Lightweight

FORGED STEEL FITTINGS in

SOCKET WELDING AND SCREW END TYPES

Light in weight and compact yet exceptionally strong — the new line of W-S 2000 lb. Forged Steel Socket Welding and Screwed Fittings assure efficient and durable service. • Especially designed for welding, W-S Socket Welding Fittings have deeper sockets with correctly proportioned walls conforming to tentative A.S.A. standards. • W-S Screwed Fittings have longer bands extending well beyond the last thread providing added strength and durability. • Both types of fittings are available in carbon steel and alloy steels. • Send for Bulletin A-3 — it gives all the facts — pressure ratings, sizes and prices — then order them from your local distributor.

THE WATSON-STILLMAN CO. • ROSELLE, NEW JERSEY

WATSON-STILLMAN

Book Reviews

Lessons for Arc Welders

[Lessons in Arc Welding. 1st ed. 1940. 136 + vi pp., 6x9 in., semi-flexible simulated leather binding. Published by The Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio. Price, 50 cents in U. S. A., 75 cents elsewhere.]

This book comprises a series of 51 lessons, based upon experiences of Arthur Madson, instructor of the Lincoln Arc Welding School, presenting in concise manner fundamental facts of welding, a knowledge of which will enable the welder to utilize the welding process successfully and economically. It is designed to be of help not only to beginners learning to arc weld, but to experienced welders and welding officials, such as supervisors, foremen and instructors.

The 51 lessons are covered in four principal sections: welding with unshielded arc electrodes; welding with shielded arc electrodes; electrodes for particular joints and metals; and hard facing. The text is graphically supplemented by line drawings and photographs, and questions on each of the lessons enable the student to check his knowledge.

Booklets, Reports and Papers

Heating Boiler Code

Announcement is made of the publication of a revised and enlarged edition of the IBR Testing and Rating Code for Low Pressure Heating Boilers. The price is 30c.

The Institute of Boiler and Radiator Manufacturers, 60 E. 42nd St., New York City, issued in 1939 a first edition of its

WARNS WHEN AIR-FILTER CLOGS WITH DIRT

DIRT clogged filters in the air circulating system mean reduced efficiency and added power costs. On the other hand, changing filters oftener than necessary represents money wasted.

Install a Hays Air-Filter Gage and know exactly just how dirty and inefficient your filters are. An indicator shows the air resistance at all times. When the resistance becomes excessive an alarm is sounded or signal flashed. A high quality precision instrument by pioneer instrument makers. Write 990 Eighth Avenue, Michigan City, Indiana for special bulletin 37-278.

HAYS AIR-FILTER GAGE

TELLS CONDITION OF FILTER AT ALL TIMES

The HAYS CORPORATION

SINCE 1905 COMBUSTION INSTRUMENTS AND CONTROL

MICHIGAN CITY, INDIANA, U.S.A.

testing and rating code with the approval of a majority of the manufacturers of cast iron boilers and radiators. The latest edition of the IBR code, which is now available in printed form, includes facts concerning its history and development and outlines in detail the procedure by which IBR ratings are obtained.

Since its original promulgation last year, the code has met with general acceptance as a means for assuring proper sizing of boilers and the elimination of confusion with respect to terms by which the performance of heating boilers is expressed. The "net IBR rating" of a boiler may be accepted as the installed radiator load where average or normal installation conditions exist.

Cast iron boilers with net rating up to approximately 1000 sq ft, produced by 14 manufacturers, now have IBR ratings, a list of which is available in a pamphlet issued by the institute, entitled IBR Ratings for Cast Iron Boilers. Price of the pamphlet is 15c. This list will be supplemented in the near future by the addition of IBR ratings for larger boilers up to 30 in. grate width.

Air Conditioning Standards

The Air Conditioning & Refrigerating Machinery Association, Southern Bldg., Washington, D.C., has published a 22 p., 5⅛ x 7¼ in. booklet on recommended practice for its members. Entitled Code of Application Engineering Standards for Air Conditioning for Comfort, its price is 50c. It is designed to supplement rather than to supplant individual company practice and data prepared and published by technical societies.

Included in the booklet is a table of design conditions for various cities for heating and cooling, showing effective temperatures for cooling for occupancies over 40 min and under 40 min. There are also tables on solar radiation through glass for different latitudes, data on infiltration, and other technical information.

FOR *Utmost Accuracy*

USE MAID-O'-MIST WATER LINE CONTROLS

FOR maintaining predetermined water levels in tanks, sterilizers, troughs, cooling systems, humidifiers, or any desired purpose . . . use the Maid-O'-Mist No. 85 Water-Boy Safety Feeder. It does every job of water level control perfectly . . . up to 75 lbs. pressure . . . and can "take it." Built to Maid-O'-Mist's rigid specifications for assured perfection in operation, the 85 Water-Boy is fool-proof in its operation. The shell is drawn from sheet brass then nickel plated, with the pipe connections silver soldered in place. The valve pin is nickel plated with a heat and oil resisting removable Neoprene washer. All levers and bearings are Monel metal. The float is nickel plated copper, and valve is protected by 100 mesh Monel Metal Filter Screen, removable for cleaning.

WATER-BOY MIDGET FEEDER

NO. 50

Is made entirely of non-ferrous metals and is 7" long over all, controlled by a nickel plated copper float which operates in water only 1" in depth. The valve is protected by a Monel metal filter screen, assuring faultless operation.

Write for Complete Catalog on Water Line Control Valves and Humidifiers Now!

MAID-O'-MIST INC.

AUTOMATIC HUMIDIFIERS FOR ALL TYPES OF HEATING SYSTEMS

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CHICAGO - - ILLINOIS

KATHABAR

CONTROLS HUMIDITY

WITHOUT CHILLING TEMPERATURES

YOU WON'T HAVE TO TOLERATE THIS

Kathabar controls humidity without affecting temperature. No re-heating or by-passing is necessary to provide a comfortable dehumidified atmosphere in any space. Kathabar gives you all the fresh air you want of the exact dryness desired regardless of weather conditions.

Kathabar enables you to control humidity and temperature separately with exact precision in each instance. Kathabar enables you to fully meet every different requirement of comfort or sensitive manufacturing operation.

Kathabar humidity control units easily are admitted into any and all air conditioning systems. Our engineers will gladly tell you how.

SURFACE COMBUSTION CORPORATION • TOLEDO, OHIO

WHAT IS KATHABAR?

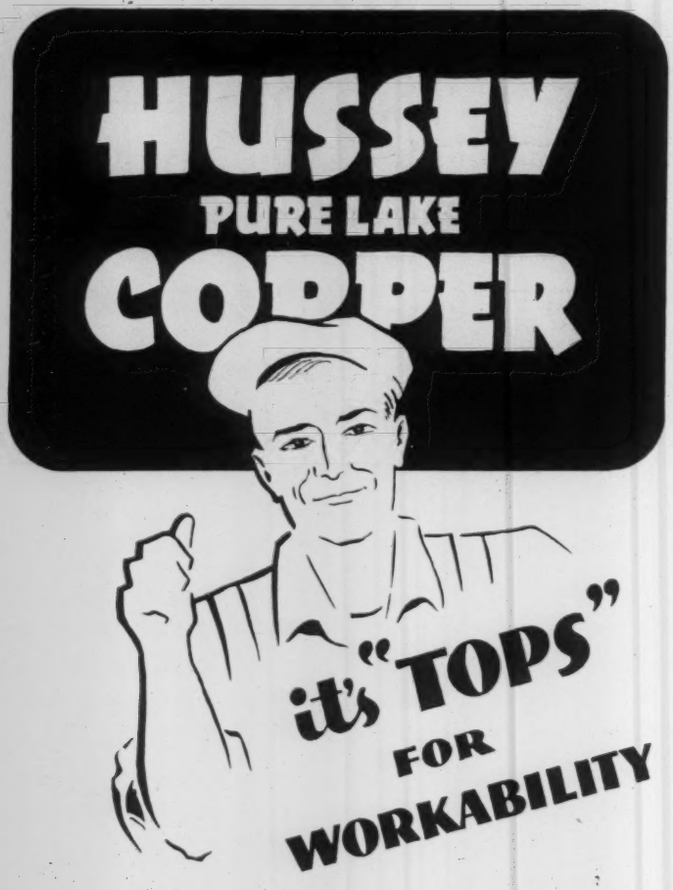
Kathabar applies the unique qualities of a chemical called Kathene, the vapor pressure or humidity of which easily can be changed at will. Air coming in contact with Kathene automatically tends to the vapor pressure of the Kathene, thus creating in treated air any desired humidity with absolute precision regardless of weather. Kathene also cleans and deodorizes the air and renders common air borne bacteria inert. Kathene is non-inflammable, non-explosive, odorless and inherently harmless. The Kathabar unit is compact, readily accommodated in practically any space and controlled by the simple action of a single valve.

- FOR COMFORT—in hotels, restaurants, public buildings, office buildings, factories, stores, theatres and recreation places.
- FOR HEALTHFUL COMFORT—in hospitals and institutions.
- FOR CONTROLLED DRYING—in factories where materials and their by-products must be dried under controlled conditions.
- FOR SPECIAL ATMOSPHERES—in industries where air conditions affect materials, processes and products.
- FOR DRY BLAST—in cupola and blast furnaces where conditioned air is required in combustion.

FOR 34 YEARS THE LARGEST MANUFACTURERS OF GAS-FIRED EQUIPMENT EXCLUSIVELY

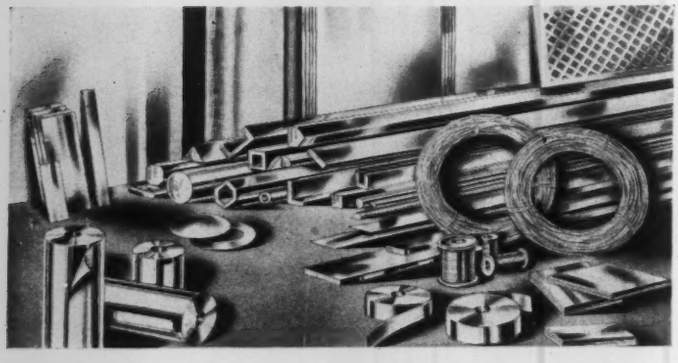
SURFACE COMBUSTION

ALSO MANUFACTURERS OF SC INDUSTRIAL FURNACES AND JANITROL GAS-FIRED DOMESTIC AND COMMERCIAL HEATING EQUIPMENT



Heating, Piping and Air Conditioning craftsmen everywhere prefer to work with genuine Hussey Pure Lake Copper because it readily shapes and conforms to the most difficult fabricating jobs—a quality peculiar to Pure Lake Copper only. It is one of the several outstanding properties which have made Hussey Pure Lake Copper famous for nearly a century—why it will pay you to specify and use Hussey Pure Lake Copper on your equipment.

C. G. HUSSEY & CO.



Copper HUSSEY Brass

(Division of Copper Range Co.)

ROLLING MILLS AND GENERAL OFFICES: PITTSBURGH, PA.

Warehouses in Principal Cities

Smoke Prevention Association Manual

The Smoke Prevention Association of America, Inc., City Hall Square Building, Chicago, Ill., has recently published the 1940 edition of its Manual of Ordinances and Requirements. It includes data on smoke abatement, air pollution and fuel combustion contributed by authorities on the subject, and gathered from various authoritative sources.

Proceedings of the association's annual convention in St. Louis last May are presented, and a model smoke abatement ordinance is given. A summary of the results of a questionnaire pertaining to smoke ordinance regulations in effect in cities throughout the United States and Canada is also included.

Copies of this 160 p. 6x9 in. paper covered booklet can be obtained from the SPA for 60c.

Conventions and Expositions

Eastern States Exposition: September 15-21, Springfield, Mass. For further information address J. H. Fifield, Eastern States Exposition, Springfield, Mass.

National Industrial Advertisers Association: Annual Conference and Exposition, September 18-20, Hotel Statler, Detroit, Mich. President, Charles McDonough, Combustion Engineering Co., Inc., 200 Madison Ave., New York, N. Y.

Iron and Steel Exposition: September 24-27, Hotel Stevens, Chicago, Ill. Sponsored by Association of Iron and Steel Engineers, 1009 Empire Bldg., Pittsburgh, Pa.

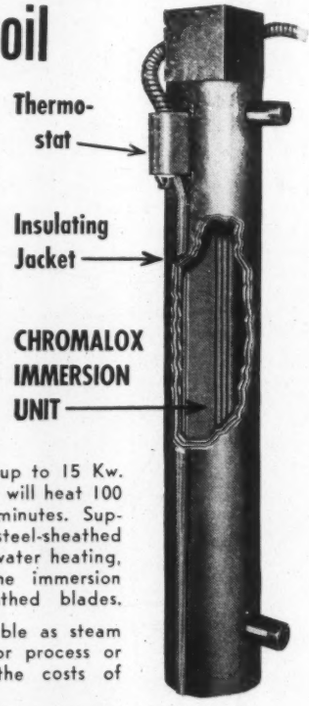
American Society of Heating and Ventilating Engineers: Fall meeting, October 14-15, Rice Hotel, Houston, Tex. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.

American Gas Association: Convention, October 7-10, Atlan-

Heavy duty ELECTRIC HEATER for water and oil

This self-contained circulation heater occupies minimum space, can be connected with ease anywhere on the line, eliminates fire hazard and fumes, and with thermostatic control, maintains the desired temperature without attention.

The heating function is supplied by a heavy-duty standard Chromalox electric immersion heater which may be controlled manually or by thermostat located on the side of the unit. Mounting lugs provide easy support of the unit, and steel jacketed insulation prevents loss of heat.



Supplied for oil heating in sizes up to 15 Kw. and for water to 24 Kw. The latter will heat 100 gallons of water 100 deg. F. in 60 minutes. Supplied for oil with steel pipe and steel-sheathed Chromalox immersion heater. For water heating, the pipe is electroplated and the immersion heater supplied with copper-sheathed blades.

These heaters have proven valuable as steam generators or hot oil circulators for process or jacketed equipment, eliminating the costs of boiler plant operation.

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tic City, N. J. Headquarters office, 420 Lexington Ave., New York, N. Y.

American Welding Society: Annual meeting, week of October 20, Cleveland Hotel, Cleveland, Ohio. Headquarters office, 33 W. 39th St., New York, N. Y. Tentative program includes papers on welding of carbon-molybdenum piping for high pressure, high temperature service, by R. W. Emerson; pipe welding for naval service, by Bela Ronay; arc and gas welding piping, by Eric Seabloom; and codes for welding pressure vessels, by D. S. Jacobus.

Power Show: 14th National Exposition of Power and Mechanical Engineering, December 2-7, Grand Central Palace, New York, N. Y. Under management of International Exposition Co., Grand Central Palace, New York, N. Y.

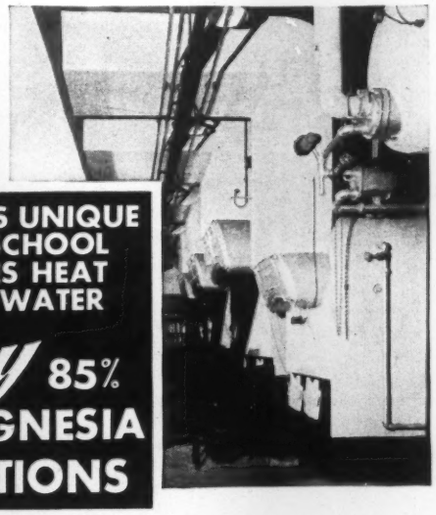
American Chemical Exposition: December 11-15, Stevens Hotel, Chicago, Ill. Under auspices of Chicago section, American Chemical Society. Exposition manager, Marcus W. Hinson, 110 N. Franklin St., Chicago, Ill.

Refrigeration and Air Conditioning Exhibition: January 13-16, Stevens Hotel, Chicago, Ill. Sponsored by Refrigeration Equipment Manufacturers Association, R. M. McClure, Executive Secretary, 111 W. Washington St., Chicago, Ill.

American Society of Heating and Ventilating Engineers: Annual meeting, January 27-29, Hotel Muehlebach, Kansas City, Mo. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.

Pacific Heating and Air Conditioning Exposition: June 16-20, Exposition Auditorium, San Francisco, Calif. Under auspices of American Society of Heating and Ventilating Engineers, and under management of Charles F. Roth, International Exposition Co., Grand Central Palace, New York, N. Y. Walter L. Fleisher is chairman of the advisory committee.

American Society for Testing Materials: Annual meeting, and exhibit of testing apparatus, June 23-27, Palmer House, Chicago, Ill. Headquarters office, 260 S. Broad St., Philadelphia, Pa.



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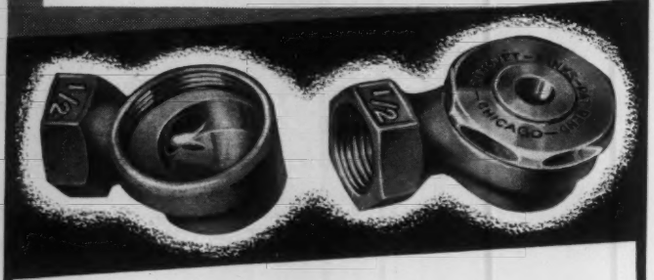

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Recent Trade Literature

For your convenience in obtaining copies of these bulletins, see coupon on page 144. If you write direct to the manufacturer, describe carefully what literature you want, as the number given first in each item is for use only when sending your request to HEATING, PIPING AND AIR CONDITIONING.

No. 3626. AIR CLEANER: Westinghouse Electric & Mfg. Co., Precipitron Dept., Cleveland, Ohio. 4 p. folder (F-8501) on the "Precipitron" electrostatic air cleaner describing how it works, its capacity, efficiency and uses.

No. 3627. AIR CONDITIONER: Carrier Corp., 302 S. Geddes St., Syracuse, N. Y. Leaflet (50J-15) on standard test laboratory air conditioner with special features to provide complete air conditioning in individual laboratories the year around. Will serve a room of approximately 1200 cu ft.

No. 3628. AIR CONDITIONING: Carrier Corp., 302 S. Geddes St., Syracuse, N. Y. 8 p. booklet (AC-131) prepared by Miss Margaret Ingels, air conditioning engineer, explaining air conditioning in terms common to "the man in the street."

No. 3629. AIR CONDITIONING: Carrier Corp., 302 S. Geddes St., Syracuse, N. Y. 16 p. catalog (AC-129) illustrating the adaptability of air conditioning to industry and showing equipment ranging from a window ventilator handling a few hundred cfm to heat diffusers delivering hundreds of thousands of Btu.

No. 3630. AIR FILTERS: Air-Maze Corp., 5200 Harvard Ave., Cleveland, Ohio. 18 p. booklet on panel type air filters with information on selection and advantages and giving performance and capacity data on the various types and sizes.

No. 3631. AIR FILTERS: American Air Filter Co., Inc., 107 Central Ave., Louisville, Ky. 16 p. bulletin (250-C) on the "Electro-Matic" self-cleaning air filter which combines elec-

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trical precipitation as an integral part of an automatic air filter. Construction and operation is explained in detail and diagrams and cut-away sections show how the two air cleaning methods are combined in a compact, self-contained unit.

No. 3632. BOILER FEEDERS AND LOW WATER CUT-OFFS: McDonnell & Miller, 400 N. Michigan Ave., Chicago, Ill. Condensed catalog and price list, and contractors' discount and net price sheet, on boiler feeders, low water cut-offs, feeder and cut-off combinations, safety valves for hot water boilers, and humidifier water level controls.

No. 3633. COMPRESSORS: York Ice Machinery Corp., Roosevelt Ave., York, Pa. Mailing piece illustrating "V/W" compressors for air conditioning and refrigeration, showing a number of installations and describing features in detail.

No. 3634. CONDENSING UNITS: General Electric Co., Air Conditioning and Commercial Refrigeration Dept., 5 Lawrence St., Bloomfield, N. J. 56 p. catalog on condensing units for air conditioning and refrigeration—prepared especially for engineers, architects and contractors—and giving performance and application data, instructions for capacity modulation, information on multiple unit operation, compressor accessories, etc. Capacities range from 5 to 60 hp.

No. 3635. CONVECTORS: Commodore Heaters Corp., 11 W. 42nd St., New York, N. Y. 8 p. bulletin (14) on "Convectofin" convection heaters for steam, hot water, vapor and vacuum systems. A departure in capacity listings is that for hot water the heat output is expressed in terms of Mb (1000 Btu). There is also a selection chart giving a key index to cabinets.

No. 3636. DEAERATING HEATERS: Permutit Co., 330 W. 42nd St., New York, N. Y. 12 p. bulletin (2357) on deaerating heaters covering their development, causes of corrosion of boilers and piping, and methods of preventing corrosion.

No. 3637. DISCHARGERS FOR HIGH PRESSURE DRAINAGE: Cochrane Corp., 3161 N. 17th St., Philadelphia, Pa. 8 p. bulletin (2935) on dischargers for high capacity, high

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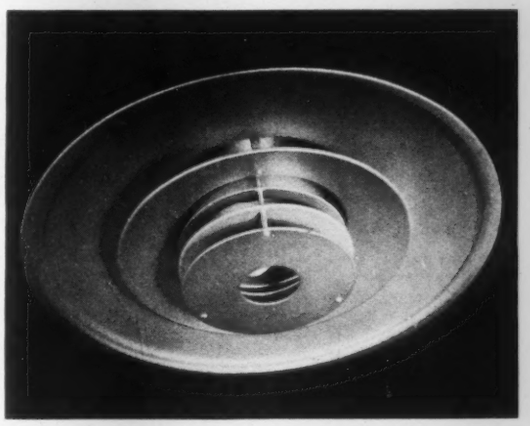

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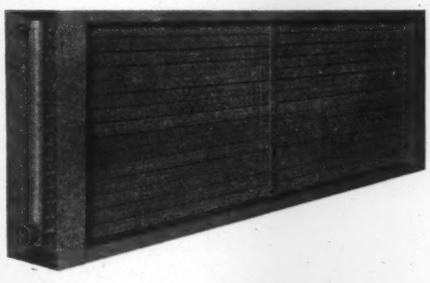

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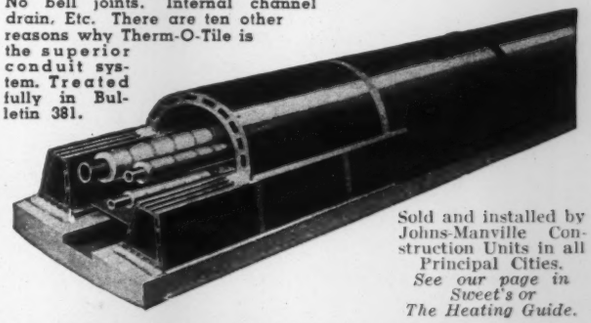

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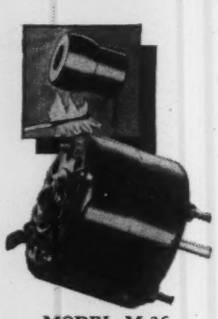

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pressure drainage. Typical applications include steam mains, steam purifiers and separators, and boiler dry drums.

No. 3638. FANS: New York Blower Co., 3155 Shields Ave., Chicago, Ill. 16 p. and 24 p. bulletins giving performance and capacity tables for slow speed and for high speed centrifugal fans, respectively, compiled for architects, engineers and contractors. Conforming to the program of industry standardization for sizes and construction as adopted by the National Association of Fan Manufacturers, complete data are presented, as well as information on physical fan laws, etc.

No. 3639. FITTINGS: Grabler Mfg. Co., 6565 Broadway, Cleveland, Ohio. 20 p. ready reference list price table covering line of "Square Gee" pipe fittings, together with data on standard weights and dimensions of fittings and pipe.

No. 3640. FITTINGS: Parker Appliance Co., 17325 Euclid Ave., Cleveland, Ohio. Wall chart on the manufacturer's combination and reducing fittings and tube couplings.

No. 3641. GAGES: F. W. Dwyer Mfg. Co., 565 W. Washington Blvd., Chicago, Ill. 4 p. bulletin (31) on stationary draft gages, with complete descriptions and illustrations as well as installation data.

No. 3642. INSTRUMENTS: Foxboro Co., 106 Neponset Ave., Foxboro, Mass. Folder on the benefits of modern instrumentation addressed to industrial plants, quoting numerous experiences of users of the equipment.

No. 3643. LEAD: Alpha Metal & Rolling Mills, Inc., 363 Hudson Ave., Brooklyn, N. Y. 4 p. card of useful information on lead products, including weights, pipe dimensions, etc.

No. 3644. MOTOR CONTROL: Electric Machinery Mfg. Co., 1331 Tyler St., N.E., Minneapolis, Minn. 8 p. bulletin (159) describing polarized field frequency automatic control for synchronous motors, its function and construction.

No. 3645. PROPORTIONING EQUIPMENT: Cochrane Corp., 3161 N. 17th St., Philadelphia, Pa. 4 p. bulletin (2985-4) on proportioning equipment for corrosive fluids, designed for accurately feeding sulphuric acid in conditioning boiler feedwater.

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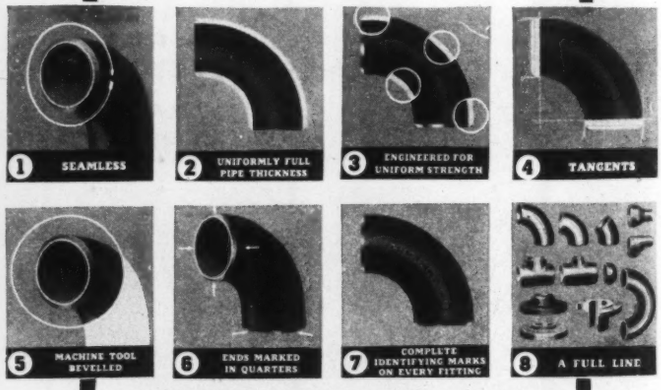
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No. 3646. RADIATOR TRAP MAINTENANCE: Water Service Laboratories, Inc., 423 W. 126th St., New York, N. Y. 2 p. leaflet on maintenance of radiator traps. This is one of a series of bulletins of maintenance hints.

No. 3647. SHEET METAL CONSTRUCTION: Dry-Zero Corp., 222 N. Bank Drive, Chicago, Ill. 4 p. bulletin describing "Lindsay Structure," a new method of construction for air conditioner cabinets, frozen food lockers, etc. The purpose is to develop strong, light construction with thin sheet metal and light framing by placing the sheets under tension in order to bind the entire structure rigidly in shape.

No. 3648. TEMPERATURE REGULATORS: Sarco Co., Inc., 183 Madison Ave., New York, N. Y. 16 p. catalog (52) covering self-operated temperature regulators for controlling flow of steam, gas, water or brine. Several new types are illustrated and described and complete capacity tables for several different valve styles to meet control problems in connection with industrial process work, water heating, air conditioning, refrigeration, etc., are presented.

No. 3649. TURBO BLOWERS: Allis-Chalmers Mfg. Co., Milwaukee. Wis. 24 p. bulletin (B6048) on single stage turbo blowers for industrial use where large volumes of air or gas are needed at pressures from 1 to 6.25 lb. Complete information is given and useful engineering data included.

No. 3650. V-BELT DRIVES: Allis-Chalmers Mfg. Co., Milwaukee, Wis. 16 p. revised bulletin (B-6051-A) on multiple v-belt "Texrope" drives, with horsepower ratings, information on the belts, and data on "Texsteel," "Texdrive" and regular cast iron sheaves. There is also information on "Vari-Pitch" speed changers ranging up to 75 hp.

No. 3651. V-BELT DRIVES: Worthington Pump and Machinery Corp., Harrison, N. J. 72 p. "Master Manual" (V-1400-E2) designed "to take the mystery out of v-belt drive selection," presenting a method for quickly determining the correct belt and sheave combination. Practical suggestions and recommendations for installation and maintenance are given.

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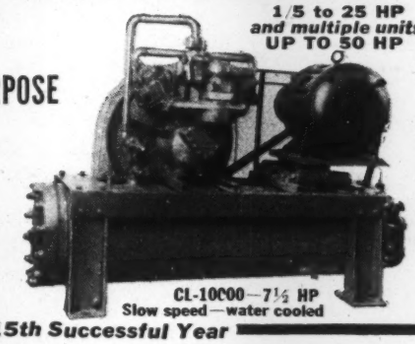

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